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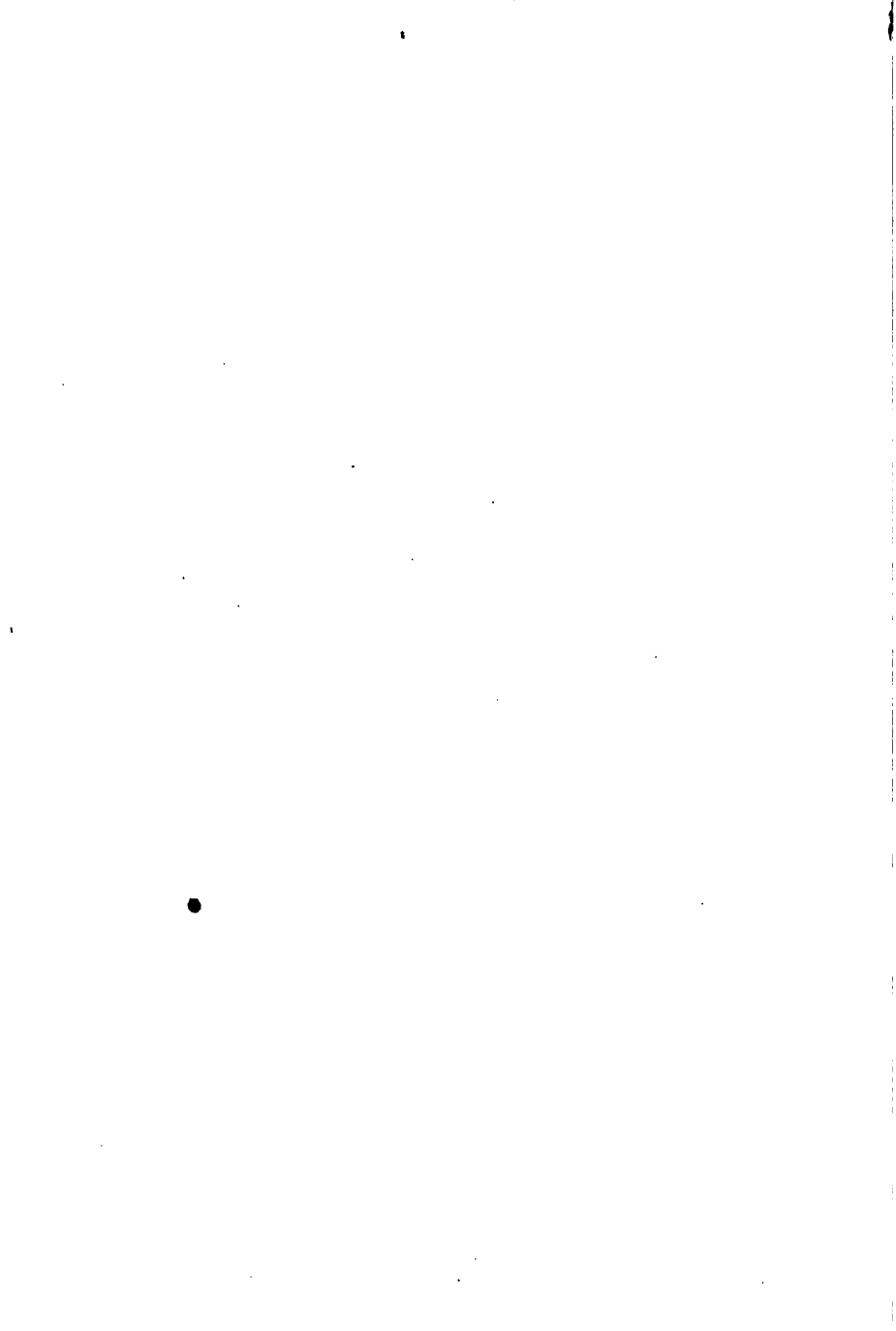


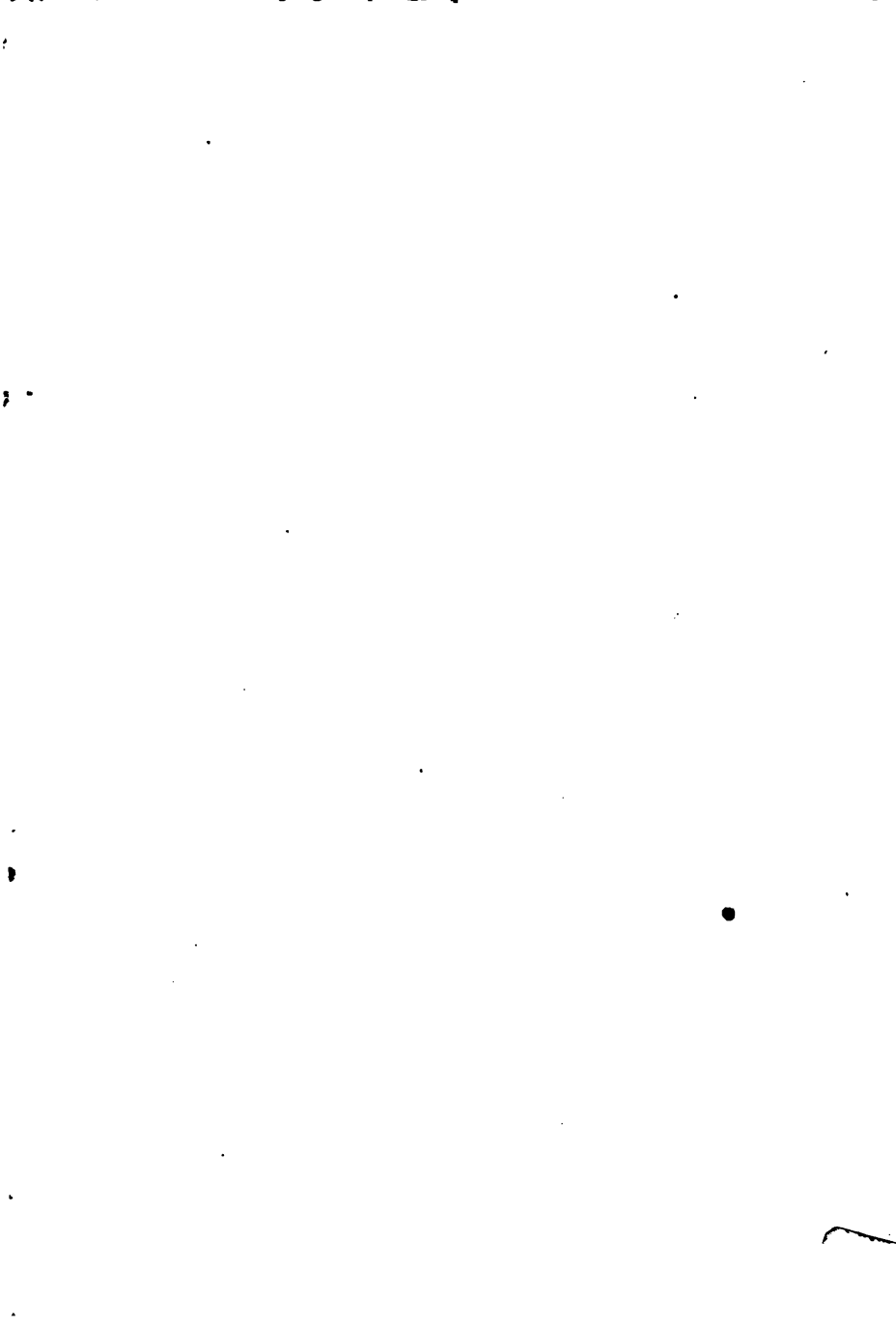
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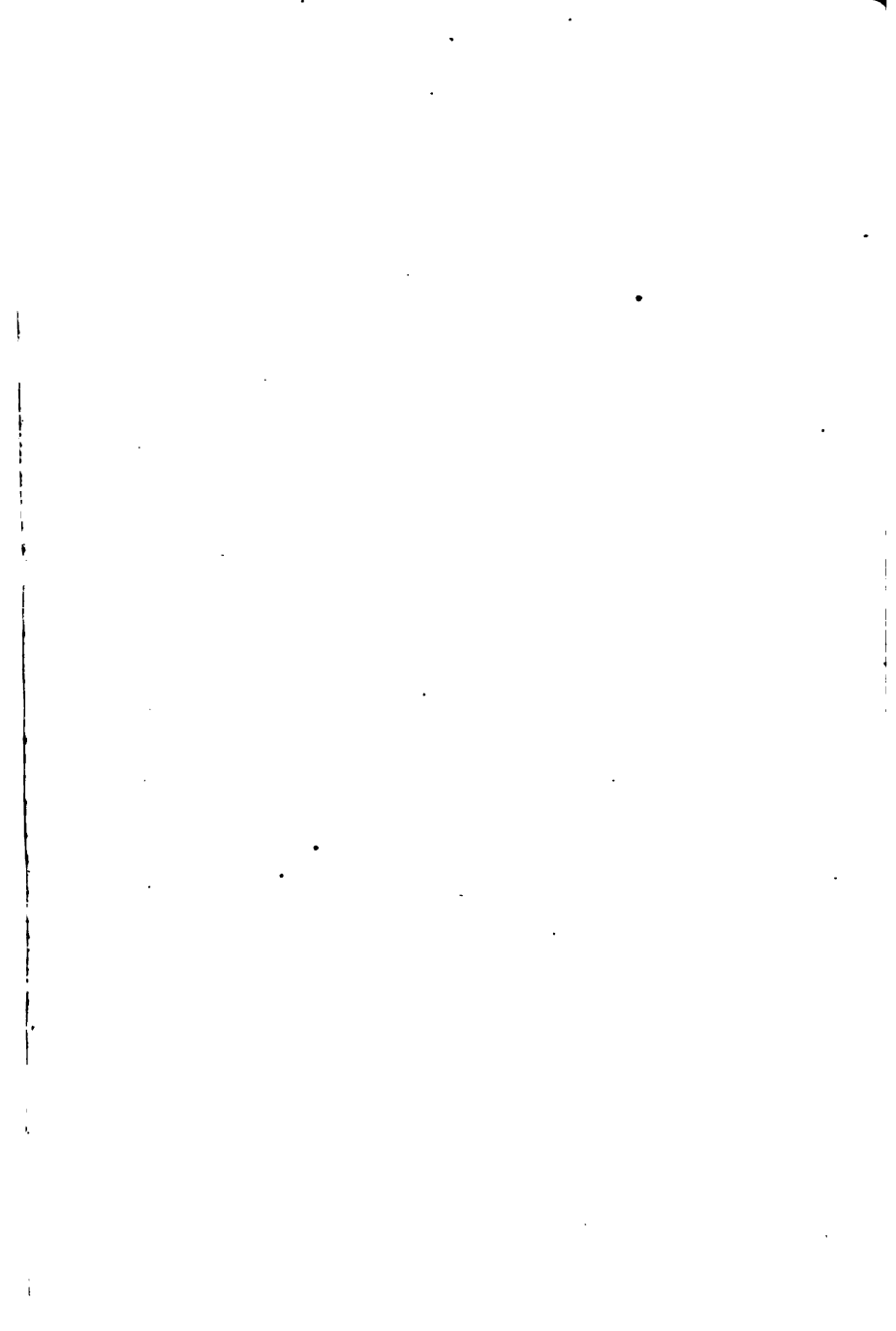
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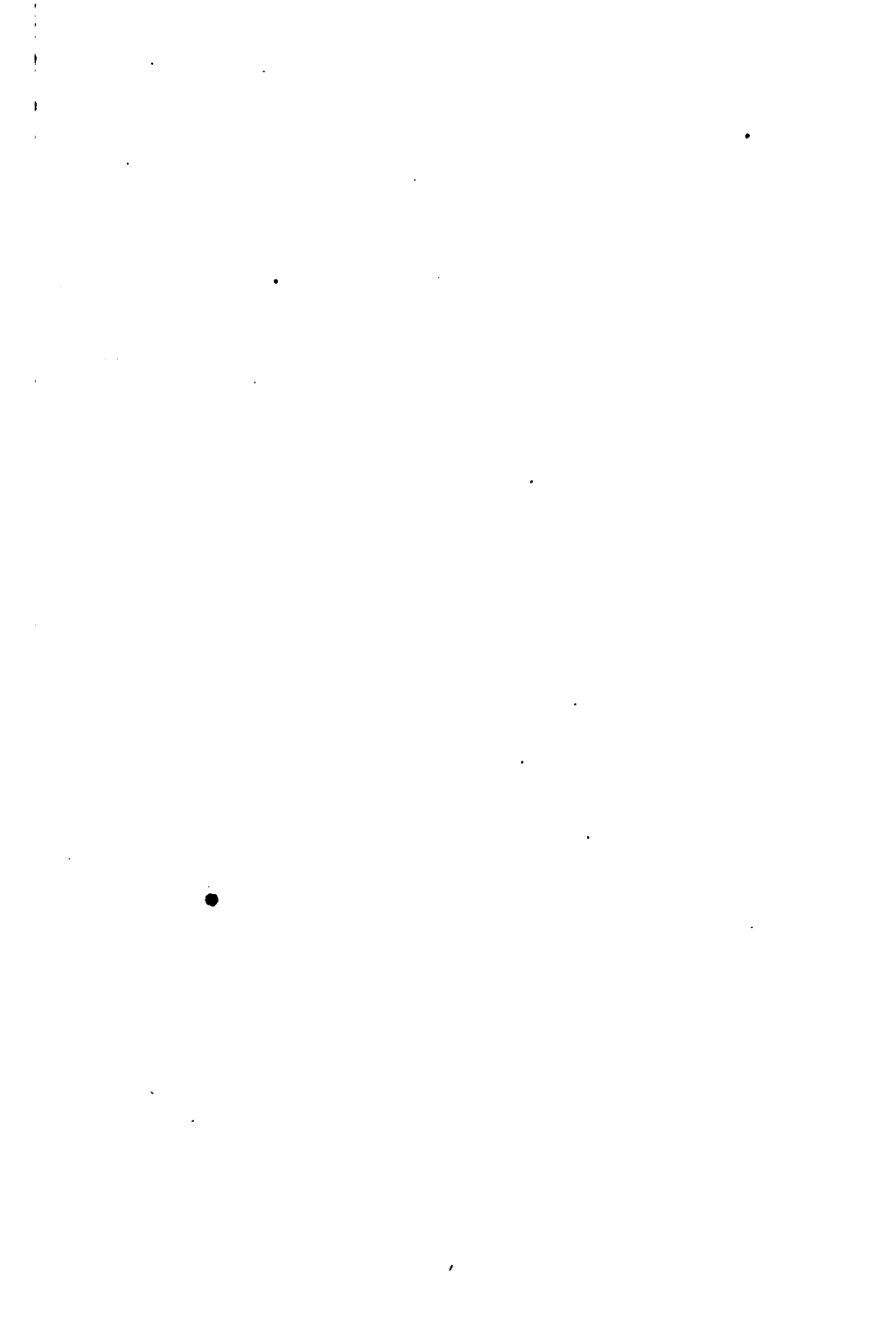
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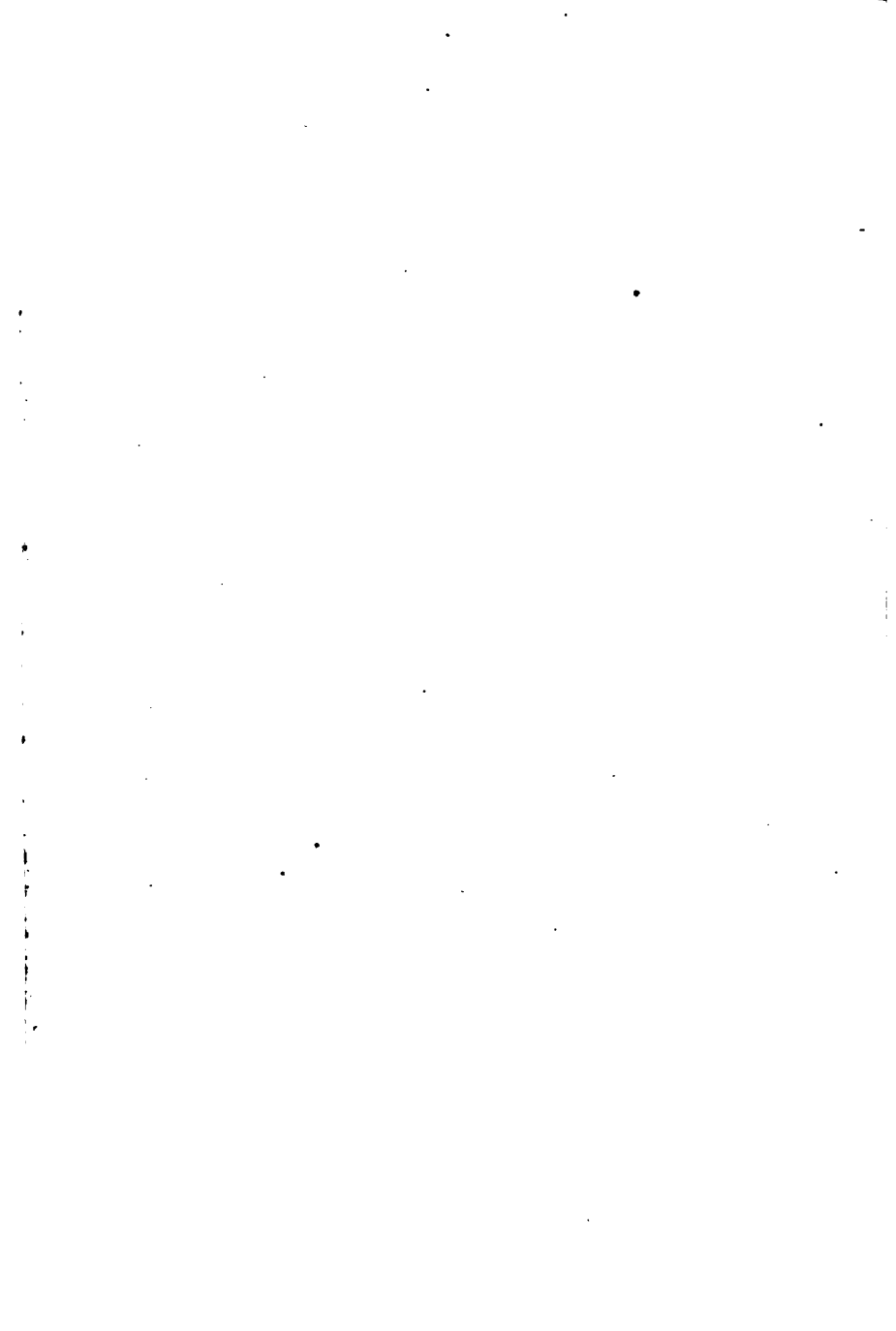
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**CHEMISTRY,**  
  
**AND**  
  
**FAMILIAR SCIENCE.**

**CONTAINING, IN A CONDENSED FORM,**  
  
**THE ELEMENTARY PRINCIPLES,**

**AND**  
  
**ALL THE MOST IMPORTANT FACTS OF**  
**THE SCIENCE.**

**BY J. DAVY.**

**Intended as a Text-Book for Academies, Schools, &c.**

**ALBANY:**  
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## PREFACE

SOME apology may appear necessary for offering a new elementary work on the science of Chemistry. The writer of these pages made use of them in the form of manuscript for several years, in instructing classes in Chemistry, in which they proved very useful in facilitating this interesting study. They were originally rewritten in the form of lectures, but through the suggestions of several individuals, they are now offered to the public, after having been rewritten in the form of questions and answers, so as to make it useful and interesting for practical elementary instruction. A work of this kind admits but little originality. The materials employed lie open to all. The writer has consulted the works of others, and has derived many principles from some of their invaluable works.

In a few instances the names of authors are introduced in the text, but the source from which extracts have been taken, and the books which have been con-

sulted are the following: Turner' Chemistry, Beck's Chemistry, Gray's Chemistry, Draper's Chemistry, Arnott's Elements of Physics, Bigelow' Technology, Parker's Philosophy, Brocklesby's Meteorology, Silliman's Chemistry and Stockhart's Chemistry.

J. DAVY.

#### PREFACE TO SECOND EDITION.

The whole work has been carefully revised, some parts condensed, and some enlarged. Many new facts and principles have also been added.

# CONTENTS

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|                                                  |    |
|--------------------------------------------------|----|
| LECTURE I.—Division of the Natural Sciences..... | 13 |
|--------------------------------------------------|----|

## PART I.

### IMPONDERABLE SUBSTANCES.

|                                                         |    |
|---------------------------------------------------------|----|
| LECTURE II.—Remarks on the Imponderables.....           | 18 |
| LECTURE III.—Radiant caloric.....                       | 22 |
| LECTURE IV.—Dew.....                                    | 26 |
| LECTURE V.—Expansion of liquids and gases.....          | 30 |
| LECTURE VI.—Thermometers.....                           | 34 |
| LECTURE VII.—Liquefaction, Vaporization, Ebullition.... | 39 |
| LECTURE VIII.—Evaporation.....                          | 44 |
| LECTURE IX.—Barometers.....                             | 49 |
| LECTURE X.—Effects of free caloric, steam.....          | 53 |
| LECTURE XI.—Sources of caloric.....                     | 59 |
| LECTURE XII.—Light.....                                 | 63 |
| LECTURE XIII.—Theories of light.....                    | 66 |
| LECTURE XIV.—Terrestrial light.....                     | 71 |
| LECTURE XV.—Electricity.....                            | 75 |
| LECTURE XVI.—Causes of electricity continued.....       | 79 |
| LECTURE XVII.—Causes of electrical excitement.....      | 81 |
| LECTURE XVIII.—Theories of electricity.....             | 84 |

|                                                     |     |
|-----------------------------------------------------|-----|
| LECTURE XIX.—Laws of electricity and lightning..... | 88  |
| LECTURE XX.—Lightning and its effects.....          | 91  |
| LECTURE XXI.—Galvanism.....                         | 94  |
| LECTURE XXII.—Effects of galvanism.....             | 97  |
| LECTURE XXIII.—Magnetism.....                       | 102 |
| LECTURE XXIV.—Electro-magnetism.....                | 106 |

## PART II.

## CHEMICAL ATTRACTION.

|                                             |     |
|---------------------------------------------|-----|
| LECTURE I.—Affinity.....                    | 112 |
| LECTURE II.—Effects of affinity.....        | 116 |
| LECTURE III.—Laws of chemical affinity..... | 118 |
| LECTURE IV.—Crystallography.....            | 121 |
| LECTURE V.—Crystallography continued.....   | 124 |
| LECTURE VI.—Nomenclature.....               | 127 |

## PART III.

## INORGANIC CHEMISTRY.

|                                             |     |
|---------------------------------------------|-----|
| LECTURE I.—Non-metallie agents, oxygen..... | 130 |
| LECTURE II.—Oxides and acids.....           | 134 |
| LECTURE III.—Hydrogen.....                  | 138 |
| LECTURE IV.—Hydrogen and water.....         | 142 |
| LECTURE V.—Nitrogen.....                    | 145 |
| LECTURE VI.—Nitrogen and air.....           | 149 |
| LECTURE VII.—Carbon.....                    | 154 |
| LECTURE VIII.—Carbonic acid.....            | 159 |
| LECTURE IX.—Carburetted hydrogen.....       | 162 |
| LECTURE X.—Combustion.....                  | 166 |
| LECTURE XI.—Flame.....                      | 170 |
| LECTURE XII.—Sulphur....                    | 174 |
| LECTURE XIII.—Phosphorous.....              | 178 |
| LECTURE XIV.—Chlorine.....                  | 181 |
| LECTURE XV.—Chloroform.....                 | 184 |
| LECTURE XVI.—Iodine and bromine.....        | 190 |
| LECTURE XVII.—Fluorine.....                 | 193 |
| LECTURE XVIII.—Silicon.....                 | 197 |

## CONTENTS.

### PART IV.

|                                                                                                                                             |     |
|---------------------------------------------------------------------------------------------------------------------------------------------|-----|
| LECTURE I.—Metals.....                                                                                                                      | 200 |
| LECTURE II.—Alloys.....                                                                                                                     | 204 |
| LECTURE III.—Classification of metals.....                                                                                                  | 208 |
| LECTURE IV.—ORDER 1. Metallic bases of the alkalies....                                                                                     | 213 |
| LECTURE V.—ORDER 2. Metals which, with oxygen, form alkaline earths.....                                                                    | 216 |
| LECTURE VI.—ORDER 3. Metallic bases of the earths.....                                                                                      | 221 |
| LECTURE VII.—Second class of metals, the oxides of which are not alkalies or earths. ORDER 1. Metals which decompose water at red heat..... | 225 |
| LECTURE VIII.—ORDER 1 continued. Cadmium.....                                                                                               | 230 |
| LECTURE IX.—ORDER 2. Metals which do not decompose water at any temperature.....                                                            | 235 |
| LECTURE X.—ORDER 2 continued. Uranium.....                                                                                                  | 241 |
| LECTURE XI.—ORDER 3. Metals, the oxides of which are decomposed by red heat.....                                                            | 249 |
| LECTURE XII.—ORDER 3 continued. Gold, platinum, palladium, rhodium &c.....                                                                  | 253 |
| LECTURE XIII.—Salts.....                                                                                                                    | 261 |
| LECTURE XIV.—ORDER 1. Oxy-salts.....                                                                                                        | 263 |
| LECTURE XV.—Nitrates.....                                                                                                                   | 270 |
| LECTURE XVI.—Chlorates, hypochlorites, phosphates, chromates.                                                                               |     |
| LECTURE XVII.—Borates, carbonates.....                                                                                                      | 279 |
| LECTURE XVIII.—ORDER 2. Hydro-salts. ORDER 3. Sulphur-salts. ORDER 4. Haloid-salts.....                                                     | 283 |

### PART V.

#### ORGANIC CHEMISTRY.

|                                                   |     |
|---------------------------------------------------|-----|
| LECTURE I.—Organic chemistry.....                 | 285 |
| LECTURE II.—Chemical phenomena of vegetation..... | 287 |
| LECTURE III.—Vegetable chemistry.....             | 290 |
| LECTURE IV.—Acetic acid.....                      | 293 |
| LECTURE V.—Tartaric acid.....                     | 297 |
| LECTURE VI.—Croconic acid.....                    | 300 |
| LECTURE VII.—Vegetable alkalies.....              | 304 |
| LECTURE VIII.—Neutral principles.....             | 307 |
| LECTURE IX.—Oils.....                             | 314 |

|                                                            |            |
|------------------------------------------------------------|------------|
| <b>/ LECTURE X.—Fats and alkalies, (soap).....</b>         | <b>317</b> |
| <b>LECTURE XI.—Volatile oils.....</b>                      | <b>319</b> |
| <b>LECTURE XII.—Resinous substances.....</b>               | <b>323</b> |
| <b>LECTURE XIII.—Resins and gum resins.....</b>            | <b>326</b> |
| <b>LECTURE XIV.—Bituminous substances.....</b>             | <b>332</b> |
| <b>LECTURE XV.—Coloring matter.....</b>                    | <b>334</b> |
| <b>LECTURE XVI.—Spiritous and ethereal substances.....</b> | <b>339</b> |
| <b>LECTURE XVII.—Fermentation.....</b>                     | <b>342</b> |
| <b>/ LECTURE XVIII.—Animal Chemistry.....</b>              | <b>345</b> |
| <b>LECTURE XIX.—Antidotes for poison.....</b>              | <b>351</b> |

## CONDUCTION OF CALORIC.

### SCIENCES.

## PLAN WORK

---

I. This work is divided into five principle parts. The first comprehends an account of the Imponderable agents, which have no appreciable weight, from whence they derive the name of imponderables.

II, The Second Part will treat of Chemical Attraction. It includes the doctrine of affinity, the laws of combination, and crystallization, and the nomenclature.

III. The third part is Inorganic Chemistry. It comprises the non-metallic agents.

IV. The Fourth Part comprises the metallic agents. The salts are divided into four orders, in the arrangement of which Turner's Chemistry has been made the basis.

Order 1. Contains the oxy-salts, or those of which the acid or base is an oxidized body.

Order 2. Contains the hydro-salts, or those which the acid or base contains hydrogen.



Order 3. Contains the sulphur-salts, or those which the electro-positive or negative ingredient is a sulphuret.

Order 4. Contains the haloid-salts, or those of which the electro-positive or negative ingredient is haloidal.

V. The Fifth Part is Organic Chemistry, which treats of those compounds which are of animal or vegetable origin. A chapter on Antidotes for Poison has been added to this part.

*Begin*

# CHEMISTRY ETC.

---

## LECTURE I.

### INTRODUCTION. DIVISION OF THE NATURAL SCIENCES.

What is Chemistry?

Chemistry is one of the natural sciences, by which we are enabled to examine the relations which affinity establishes between bodies.

Are there any of the other sciences connected with it?

Natural Philosophy and Natural History are intimately connected with Chemistry, and from this fact they have been termed sister sciences.

What is Natural Philosophy?

It is the science which treats of the powers and properties of natural bodies, their mutual action one on another, and the laws and operations of the material world.

Into how many branches may Natural History be divided?

Three. 1st. Zoology, which treats of animals. 2d. Botany of the classification, appearances, habits and properties of vegetables.

3d. Mineralogy of stones, earths, &c. Geology of minerals as they exist in masses, forming rocks, is a branch of Mineralogy.

What is that science called which is now about to engage our attention?

Chemistry.

Is it a useful study?

There is no science which more eminently deserves to enter into the plan of a good education than Chemistry. We may even affirm that the study of this science is almost indispensably necessary to prevent us from being strangers in the midst of the beings and phenomena which surround us.

Does it bear any relation to the useful arts?

Chemistry bears the same relation to most of the arts and sciences that mathematics do to those which depend on their principles, and many of the inventions of modern days owe their origin to this science.

To what persons is a knowledge of Chemistry useful?

A knowledge of chemistry is of great use to all persons, but more particularly to those who are engaged in the common affairs of life. The glass maker exhibits chemical phenomena in combining alkaline, saline, metallic and earthy materials. The tanner, by a chemical process, converts the skin of animals into the various kinds of leather, which is found very useful in the manufacturing of shoes, &c. It

shows the miner the metal concealed in rocks, and aids him in smelting and working them.

Of what particular benefit is it to the agriculturalist?

A knowledge of chemistry enables him to examine the composition of the various strata of which the soil is composed, and instructs him how to enrich it so as to be susceptible of cultivation.

Has the physician received much assistance from chemistry?

Chemistry is considered as indispensable in the medical profession, it has enabled the physician to analyze the various elements necessary to form a compound. He finds several simples, when united, efficacious in the relief of a particular disease; and by the aid of this science, he can determine what proportions will unite with substances without decomposing them.

How do chemists divide substances?

Into simple and compound.

What is a simple substance?

It is one which has never been decomposed.

What is a compound substance?

It is one which is composed of two or more simple bodies.

How is the composition of bodies ascertained?

By two methods, analysis and synthesis.

Define them.

Analysis, is the separating of a substance into its elementary parts, and synthesis is the reunion of the parts to form a compound.

How many of the elementary substances are there?

There are about sixty only of the elementary substances as yet known, which enter into combination with each other.

With how many are we acquainted?

We are intimately acquainted with eighteen; the remainder are rare.

Upon what is the science of chemistry based?

The science of chemistry is based upon experiments, and the name of Experimental Philosophy has therefore been applied to it.

How many methods of experimenting are there?

There are three: determinative, demonstrative and productive.

Define them.

Determinative is the process of telling what a body is; demonstrative, is the process of proving by experiment, and productive is the uniting of elements to form a body.

How do we arrive at a knowledge of Chemistry?

The process by which we arrive at a knowledge of chemistry, is solution, fusion, ignition, evaporation and crystalization.

Does the study of the sciences tend to elevate the human mind?

The question has often been asked: "Does the study of the sciences tend to establish the mind in the truths of religion, and promote christian humility; or rather, does not science put nature in the place of God, and heighten the pride of man, by filling him with lofty notions of his own powers, which can thus penetrate the mysteries of creation;" It is true that such effects may arise from a superficial study of the sciences, but when we become so deeply engaged in philosophical investigations as to forget Him whose works we study, we are wandering from the path of true knowledge.

# **PART I.**

## **IMPONDERABLE SUBSTANCES.**

---

### **LECTURE II.**

#### **GENERAL REMARKS ON THE IMPONDERABLES.**

From what do all the changes arise to which material things are subject ?

From the action of the imponderable agents.

Why are they called imponderable ?

Because they have no appreciable weight.

What may they be considered ?

As invisible fluids, pervading all nature.

What are the names of the imponderable agents ?

The imponderable agents are caloric, light, electricity, magnetism and galvanism.

What is caloric ?

Caloric is the agent which produces the sensation of heat.

Then what do you mean by caloric ?

Heat, which pervades all bodies, and causes an expansion or separation of the atoms.

Then is caloric a ponderable or imponderable substance ?

Caloric has been proved an imponderable substance, by its being so very light, that there is no appreciable difference in the weight of a body, whether it is hot or cold.

In what state does caloric exist ?

In a free or sensible state, and in a latent or insensible.

What is sensible caloric ?

Sensible caloric is that which is capable of producing the sensation of heat.

What is the meaning of latent ?

Concealed or hidden.

What is insensible caloric ?

Insensible caloric produces no sensation, but exists in a state of apparent combination with bodies.

What is the most important property of free caloric ?

Its tendency to an equilibrium.

In how many ways is it conducted ?

Two, conduction and radiation.

What is meant by conduction ?

The passage of caloric through a body, particle to particle.

Give an example of conduction.

Place pieces of phosphorus along an iron rod, and apply heat to one end of it, the pro-



gress of the caloric will be indicated by its igniting the phosphorus.

Do different substances conduct caloric with different degrees of rapidity.

They do. Take a tin plate and place upon it different substances, such as copper, zinc, china, marble and paper; lay upon each substance a small piece of phosphorus, and place beneath the tin plate a lighted lamp filled with alcohol, and the substance will ignite according to the different degrees of conduction.

From what do the different degrees of rapidity arise, with which substances conduct caloric?

From their different densities.

Which bodies are the best conductors of heat?

Dense solid bodies, such as metals and stone.

Which metals conduct with the greatest rapidity?

Gold, silver and copper.

Which conduct with least rapidity?

Those which are least dense, such as fur and down.

Do liquids conduct caloric?

They do directly from particle to particle in a feeble degree.

Give an example.

Place light beneath a vessel of water which contain particles of amber; when the water

becomes heated, the particles of amber rise, and the cold ones descend.

Can heat be produced by friction ?

It can ; the savages light their fires by rubbing together two pieces of wood.

Is the earth a good conductor of heat ?

The earth is not a good conductor, but brass is.

Why are coffee pots made with wooded or ivory handles ?

Because if metal were used, it would conduct the heat so readily, that the hand could not bear to touch them.

From whence 'do we derive our conducted heat ?

From the air, a fluid which constantly touches our persons.

Which is the most agreeable, radiant or conducted ?

Radiant is the most agreeable.

## LECTURE III.

### RADIANT CALORIC.

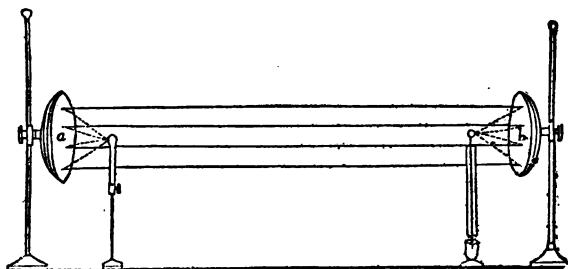
What is Radiation ?

Radiation is the emission of rays, and thus the sun emits rays of light and heat in all directions.

What do you mean by radiant caloric ?

The caloric which flows from a heated body is called radiant, because it is thrown off in all directions, like the rays of light from a radiant point.

FIG. 1.



A and B, concave mirrors, fixed on stands. C, heated bullet, placed in the focus of the mirror A. D, thermometer, with its bulb placed in the focus of the mirror B. The dotted lines show the course of the rays of heat diverging from the heated ball, C, then rendered parallel by the mirror A, whence they are reflected to the mirror B, from which they converge, and fall upon the thermometer in its focus D.

Can radiant caloric be reflected from smooth surfaces?

They can, though polished ones do not radiate so rapidly as those which are rough.

Give an example.

Place two concave mirrors at opposite sides of the table. If we then put a red hot cannon ball in the focus of one of the mirrors, it will instantly affect a thermometer in the focus of the other.

When radiant caloric falls upon rough, dark colored, or opaque bodies, what becomes of it?

The caloric becomes absorbed.

Through what kind of bodies is caloric transmitted?

Through transparent bodies.

How many theories have been formed in regard to the radiation of caloric?

Two theories,

Who were their authors?

Pictet and Prevost.

What is the theory of Professor Pictet of Geneva?

Pictet supposes that a hot body will radiate caloric to surrounding colder bodies, until the equilibrium is restored, when the radiation ceases.

What is the theory of Prevost?

Prevost supposes that all bodies, whatever

be their temperature, are constantly giving out and receiving radiant caloric.

Which theory is the one most genenerally adopted?

The theory of Prevost.

If they receive from surrounding bodies more than they radiate, what becomes of the temperature?

The temperature becomes increased, but if less it is reduced.

What is Cold?

A negative term, which merely implies an absence of caloric.

What is affirmed by some persons in regard to the rays of the moon?

Some persons affirm that the rays of the moon are cold.

Has there been any experiments made to prove this?

A gentleman of Baltimore made a large glass bulb, which terminated in a long, narrow tube, immersed in liquid. The bulb he painted black, so as to absorb as much heat as possible; he put this instrument in the focus of the moon's rays, and found, to his great astonishment, that the liquid rose. He supposed that this experiment proved beyond doubt that the moon's rays were cold.

Can this phenomenon be accounted for otherwise?

It can ; the thermometer radiated more heat than it received ; the earth being cool, and consequently its temperature became reduced.

How is the cooling of bodies effected ?

By the radiation and conduction of caloric.

## LECTURE IV.

### DEW.

On what does the formation of dew and frost depend?

The radiation of heat.

What is the earth during the day constantly absorbing?

The sun's rays, which become much heated.

When this great source of heat is withdrawn, what becomes of the earth's temperature?

The earth radiates its heat, and not receiving as much as it radiates, its temperature is consequently reduced.

What are the effects of this reduction?

It condenses the moisture of the air in the form of globules of water, which settle upon the leaves and grass, and is called dew.

What theory furnishes a beautiful explanation of these curious facts.

Dr. Wells's.

Can you relate the theory?

"During the day, the various bodies on the surface of the earth, receiving the rays of the sun, become warm, but at night fall, when the sky is unclouded, they begin to cool, for the process of radiation continuing without any

source of supply, their temperature must descend. While the sun shone, they received as much heat from him as they gave forth to the sky; but when he sets, the supply is cut off, and they therefore cool; and as there is always moisture, their temperature descending, by and by the dew point is reached: they become cold enough to condense water from the surrounding air, and this is the dew."

Can you tell me why a pitcher filled with cold water, or a bottle of wine taken fresh from the cellar, (in summer, particularly,) will soon be covered with dew?

The bottle being colder than the surrounding air, absorbs caloric from it, the moisture which that air contained becomes visible, and forms dew, which is deposited on the bottle.

When the air is condensed in a crystalline form, what is it called?

Air condensed in a crystalline form is denominated frost.

But why is there no dew or frost in a cloudy night?

The clouds stop the passage of caloric which is radiated from the earth, and is reflected back again; this increases the temperature of the earth, which is therefore too high for any condensation of the air to take place.

Why is dew deposited only on a clear night?

Because the surface of the ground radiates heat most freely in a clear night.



When there is a great quantity of dew in the morning, what does that indicate?

That the day will be pleasant, because dew is never deposited in dull, cloudy weather.

When is dew most copiously distilled?

Dew is most copiously distilled after a warm day in summer.

Why is dew distilled most copiously after a warm day?

Because the surface of the hot earth radiates heat more freely at sunset, and chills the vapor which condenses into dew.

Why is evening dew injurious to health?

The evening dew is filled with noxious exhalations from the earth, and for this reason it is injurious to health.

What is hoar frost?

Hoar frost is dew, frozen the moment it falls.

Is heat produced by the sun, found to differ according to the surface exposed?

Dr. Franklin proved that as a general rule, dark colors absorb most light and heat. He lay pieces of cloth of different colors on the snow, and exposed them during a given period to the sun's rays, then noted the different depths to which, by melting of the snow, the pieces sank, they consequently acquired heat in proportion to the darkness of their colors.

Is white a good dress for summer?

It is ; the heat may be repelled ; it is also good for winter, because it radiates a little.

Is it a wise provision in our Heavenly Father to give the polar animal white fur ?

It is ; the fur of many animals changes color as winter approaches.

Why are birds covered with down or feathers ?

Because down and feathers are bad conductors of heat.

## LECTURE V.

### EFFECTS OF FREE CALORIC

#### EXPANSION OF LIQUIDS AND GASES.

What are the effects of caloric?

The general effects of caloric are expansion, liquefaction and vaporization.

Does caloric expand bodies?

Caloric expands all bodies, liquids more than solids, and gases more than either.

Give an example where caloric expands solids.

A familiar demonstration of the fact may be afforded by adapting a ring to an iron rod, the former being just large enough to permit the latter to pass through while cold. The rod when heated will not pass through the ring.

How is it proved that equal additions of caloric expand some bodies more than others?

By taking two glass bulbs terminating in long narrow tubes, one filled with alcohol, and the other with sulphuric acid; but if the bulbs be immersed in hot water, the alcohol will rise higher in the tube than the sulphuric acid,

proving that its expansive power is the greater of the two.

Give an example to show that caloric expands liquids more than solids.

Place a common thermometer into a jar of hot water. The bulb of the thermometer expands, and its capacity increases; but the mercury will be more expanded, and rise in the tube.

How is it proved that caloric expands gases more than either solid or liquids?

By taking a glass bulb which terminates in a tube, the end of which is immersed in liquid. If we first heat, and then cool it by means of pouring ether on it, we find that the liquid rapidly rises, but if heated again, it expands and forces the liquid down.

Does heat expand air?

Yes: Take a bladder partially filled with air, tie up the neck, and place it before the fire, and the result will be, that the air in the bladder will expand and cause it to burst.

Upon what does the form which matters assumes depend?

On the relative force of caloric and cohesion.

What effect has heat on bodies?

Heat expands bodies, and the absence of it contracts them.

How long does water contract before it commences to expand?

Water contracts till the degree of 39 Fahrenheit's thermometer.

Is this a wise provision of nature?

It is; for as the ice expands, it occupies more surface, and floats upon the water. If it contracts, in the course of a few weeks, all our rivers and lakes would be frozen entirely, and to such a depth that the summer's sun would have but little effect upon them.

When cohesion preponderates over caloric, what form does matter assume?

Matter assumes a solid form, but when the force of caloric is greater it becomes liquid or gas; and when the excess of caloric is very high, it is always a gas.

What is it that determines the form of bodies?

Heat determines the form of bodies.

How can caloric affect our measures of time?

When the temperature rises, the rod of a pendulum lengthens, and its vibrations are made more slowly, and the clock to which it is attached loses time. When the temperature declines, the pendulum shortens; it beats too quick, and the clock gains.

Can this difficulty be obviated?

Many contrivances have been invented, such as the gridiron pendulum, &c.

Are all kinds of machinery affected by the law of expansion and contraction?

They are. M. Molard, at Paris, a few years since, availed himself of this principle, to restore to their perpendicular direction two opposite walls of a gallery, which had been pressed out by incumbent weight. Through holes in the walls, several strong iron bars were introduced, so as to cross the apartment, with the ends projecting, upon which strong iron plates were screwed. The bars were then heated, and while hot, the plates were screwed up. On cooling, the bars contracted, and drew the walls together. By repeating this process several times, they were restored to their original position.

How were balloons first sent up?

Balloons were first filled with air which had been expanded by heat.

On what do the phenomena of winds depend?

The phenomena of winds depend upon the expansion of the air by the heat of the sun.

Where is one of the most ingenious and useful applications of this law to be found?

In an instrument called the thermometer.

2nd

## LECTURE VI.

### THE THERMOMETER.

What is a thermometer?

The thermometer is an instrument to show how hot or how cold any thing is.

How is the air thermometer constructed?

Take a glass tube eighteen inches long, open at one end, and blown into a bulb at the other. Then fill the bulb with common air, and invert the tube into a cup which contains some colored liquid. If the bulb be then grasped in the warm hand, the air within being expanded, will be seen bubbling up through the liquid. The air in the bulb, by its expansion, causes the water in the tube to sink, and by its contraction, the pressure of the atmosphere causes it to rise.

In what does the advantage of the air thermometer consist?

In the great amount of the expansion of air, which, by a given elevation of temperature, is increased in bulk above twenty times more than mercury. Hence it is adapted to detect minute changes, which the mercurial thermometer would scarcely discover.

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By whom was the air thermometer first made?

The air thermometer was first made by Sanctoria, of Padua, Italy, who lived about the beginning of the seventeenth century.

What objection was raised against it?

The air in the bulb, by its expansion, causes the water in the tube to sink.

How is it sustained?

The pressure of the atmosphere causes it to rise.

Has it been much improved?

It has, and the thermometers most commonly used are filled with mercury.

Are there any other kinds?

There are several other scales used, such as the Differential, Fahrenheit's, Mercurial, Reaumur's, Centigrade, &c.

How is the differential thermometer constructed?

It consists of two glass bulbs, joined together by a glass tube bent twice at right angles. The balls contain air, but the tube is filled with sulphuric acid colored with carmine. Upon applying either side to a heated body, the sulphuric acid will rise in the other side, different spaces, according to the different intensities of heat.

Who constructed the differential thermometer?



Mr. Leslie, and it is used for determining differences of temperature at small distances.

How are thermometers generally made?

By taking a glass tube highly heated, and plunging it in mercury until it is entirely filled, and contains nothing but mercury. The tube is then sealed, two points upon it are ascertained, viz: the boiling point, found by plunging it into boiling water; and the freezing, in a mixture of salt and snow.

What is meant by the scale of a thermometer?

The scale of a thermometer is merely a flat plate placed behind the tube, and marked with small divisions to show what height the fluid rises.

By what name is this thermometer called?

Fahrenheit's: it is divided into 180 degrees, and is most commonly used in America and England.

How is the Centigrade divided?

The centigrade is divided, between the two fixed points, into one hundred parts; the freezing point is  $0^{\circ}$ , and the boiling point  $100^{\circ}$ , and it is generally used in France.

How is Reaumur's scale divided?

Reaumur's scale is divided into eighty degrees, and is used in some parts of Europe.

Under what circumstances are alcohol thermometers used?

Alcohol thermometers are used when very low temperatures have to be measured, such as approach or are below the freezing point of quicksilver; we resort to thermometers filled with alcohol, tinged with some coloring matter to make its movements visible.

Will thermometers bear any degree of heat?

No, for if the temperature were much above the highest degree marked on the scale of the thermometer, the mercury, by its expansion, would burst the tube; and no thermometer can, on any account, be applied to a temperature higher than the boiling point of the liquid used in its construction; for on the liquid beginning to boil, the steam would burst the tube.

What instrument has been used for measuring degrees of heat higher than can be determined by the thermometer?

A pyrometer.

How is a pyrometer constructed?

A pyrometer consists of a bar of platinum or soft iron, so placed, in a case of black lead earthen ware, that when exposed to a high temperature, the bar, expanding more than the case, pushes forward an index of porcelain.

Of what are they made?

Pyrometers are made of clay or platinum.

By what other name has it been called?

Wedgewood's Pyrometer, or fire measurer.

Whose pyrometer has been considered the best?

The pyrometer of Daniell, of London, is considered the best now in use.

*Begin*

## LECTURE VII.

What is liquefaction?

The state of being melted; as ice is melted by the heat of the sun.

How is liquefaction produced.

Most generally by the direct application of heat.

If a solid be sufficiently heated, what will it become?

Liquid, and then gaseous.

What is the temperature called at which liquefaction takes place?

The melting point, or point of fusion.

What do bodies absorb in passing from a solid to a liquid state?

Caloric.

Give an example.

If a pound of water at  $32^{\circ}$  be mixed with a pound of water at  $172^{\circ}$ , the temperature will be intermediate between them,  $102^{\circ}$ ; but if a pound of water at  $172^{\circ}$  be added to a pound of ice at  $32^{\circ}$ , the ice will quickly dis-

solve, and on placing a thermometer in the mixture, it will be found to stand, not at  $102^{\circ}$  but at  $32^{\circ}$ .

In what two states does Dr. Black suppose heat to exist?

In a latent or combined, and free or uncombined.

When a solid becomes liquid, what does he suppose becomes of its free caloric?

He supposes that a quantity of caloric combines with that substance, and thus becomes latent or insensible, and incapable of acting on the thermometer; and therefore liquefaction always takes place gradually. On the other hand, when a liquid is cooled down to a certain point, it parts with its caloric of fluidity, which now becomes sensible, and the liquid takes the solid form.

How many degrees of heat are absorbed by ice passing into the condition of water?

About  $140^{\circ}$  of heat.

Into what are aeriform substances divided?

Into vapors and gasses.

What appears to be the cause of vaporization?

Heat.

What is meant by vaporization?

The conversion of liquid and solid sub-

stances into vapor; as snow or water is converted into vapor by the heat of the sun.

Into how many ways may liquids be vaporised?

Two, evaporation and ebullition.

What constitutes the difference between evaporation and vaporization?

Evaporation is effected by exposure to the air, and takes place quietly, without boiling; while vaporization requires the air of sufficient heat to produce ebullition.

What is ebullition?

Ebullition is occasioned by the formation of bubbles of vapor within the body of the evaporating liquid, which rise to the surface and then break.

What is the temperature called at which a liquid is converted by ebullition into vapor?

Its boiling point.

What are the chief circumstances which modify the boiling point of the same liquid?

The pressure of the atmosphere.

When atmospheric pressure is diminished, what becomes of their boiling temperature?

Fluids then boil at a lower temperature than under the ordinary pressure. Thus water which has been removed from the fire, and ceased to boil, has its ebullition renewed when it is placed under a receiver, the air

of which is quickly exhausted by an air pump.

Give an experiment.

Boil water in a florence flask, then remove it from the fire and cork it tight; the ebullition will instantly cease, because the steam formed will press upon the surface; but by pouring on cold water and condensing the steam, it will boil violently. Pour on warm water, and it will stop boiling.

To what was the renewal of the ebullition owing?

To the formation of an imperfect vacuum over the hot water by the condensation of steam; and the suspension of boiling on the renewal of heat, to the pressure on the surface, occasioned by the formation of fresh steam.

When atmospheric pressure is increased, what becomes of their boiling temperature?

Fluids then require a higher temperature to produce their ebullition.

Can water be heated under common circumstances beyond  $212^{\circ}$ .

It cannot, because it then requires such an expansive force as enables it to overcome the atmospheric pressure, and fly off in the form of vapor; but if subjected to sufficient pressure, it may be heated to any extent without boiling.

When water is heated to the temperature of  $212^{\circ}$ , to what is its force upon each square inch equal?

Fifteen pounds.

Can you prove that the pressure of the air prevents ebullition?

A watch glass, containing water, may be placed over a small vessel, containing sulphuric acid, and put under the receiver. When the air is exhausted, vapor will freely rise from the water, and be quickly absorbed by the acid. A great degree of cold is thus produced, and the water will freeze.



## LECTURE VIII.

### EVAPORATION.

What is evaporation ?

Evaporation is the conversion of bodies into vapor at common temperatures.

What is the cause of evaporation ?

It has been shown that caloric is the true and only cause of evaporation.

What are the chief circumstances which influence evaporation ?

Extent of surface, and the state of the atmosphere in respect to temperature, moisture and dryness.

As a large quantity of caloric passes from a sensible to an insensible state during the formation of vapor what follows ?

That cold should be generated by evaporation.

What experiment will prove this ?

If a few drops of ether be allowed to fall upon the hand, a strong sensation of cold will be excited during the evaporation ; or if the bulb of a thermometer, covered with lint, be moist-

ened with ether, the production of cold will be marked by the mercury.

If a person bathes the temples with ether, why does it allay inflammation?

Because ether evaporates quickly, absorbs the heat from the head, and produces a sensation of cold?

Does ether serve any other purposes?

Ether is very useful in relieving a scald or burn; it is also very frequently used as a stimulus with a little water.

Does the action of the cryophorus, by Dr. Wollaston, depend on the principle of evaporation?

It does; it consists of two glass balls, perfectly free from air, and joined together by a tube. One of the balls contains a portion of distilled water, while the other parts of the instrument, which appear empty, are full of gaseous vapor, which checks the evaporation from the water, by the pressure it exerts upon its surface. But when the empty ball is plunged into a freezing mixture, all the vapor within it is condensed; evaporation commences from the surface of the water in the other ball, and it is frozen in two or three minutes by the cold thus produced.

Is evaporation more rapid in some liquids than in others.

It is, and the increase of pressure checks, and the diminution of it promotes it.

What are some of the uses of evaporation ?

Evaporation is fitted for cooling apartments, and tends to defend the animal as well as the vegetable system from external heat.

Why does sprinkling a hot room with water cool it ?

Because the heat of the room causes a rapid evaporation of the sprinkled water, and as the water evaporates, it absorbs heat from the room which cools it

Why does watering the streets in summer cool them ?

Because they part with their heat to promote the evaporation of the water sprinkled on them.

Is evaporation most rapid in hot or cold weather ?

Cold weather.

Is the human body able to sustain great degrees of heat ?

Individuals have been known to expose themselves for several minutes in ovens, where meat was baking and water boiling, without suffering any inconvenience, and also to a very low temperature, with but little inconvenience.

Would they have been enabled to do this if vital principle was destroyed ?

No, for as soon as life becomes extinct, the skin becomes green and livid, the eyes sink in

their socket, and the body is then incapable of resisting either heat or cold.

Is health generally injured, when the temperature of the body is reduced below the natural standard ?

It is, because the ballance of the circulation is destroyed.

Should persons who take violent exercise wear very thick clothing ?

They should not, because thick clothing prevents the perspiration from evaporating, and it is injurious to health.

Does the atmosphere contain any watery vapor ?

It does, and Mr. Daniel has contrived an instrument for measuring the amount of vapor in the air.

How is it constructed ?

It consists of a bulb of glass, which can be cooled to any desired degree, from being connected with another bulb enveloped in an evaporating liquid; and when moisture begins visibly to settle upon the first, its temperature is exhibited on a thermometer enclosed within it.

When the elevation is very great to which moisture is suddenly carried, the fall of temperature is proportional, and the separating water becomes what ?

Snow instead of rain.

Can this phenomena be illustrated?

It can, by means of a great Hiero's fountain.

How may it be used?

To raise water, or to project it upward in the form of a jet.

What is snow?

Snow is the condensed vapor of the air frozen and precipitated to the earth.

What is the use of snow?

It keeps the earth warm and nourishes it.

What is rain?

Rain is the vapor of the clouds or air, condensed and precipitated to the earth.

Does the pressure of the atmosphere vary at different times on the surface of the earth?

It does, as we ascend high mountains the pressure diminishes rapidly.

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## LECTURE IX.

### THE BAROMETER.

What is the barometer?

A barometer is an instrument, by which the variation of the atmosphere is measured. It was discovered by Torricelli, an Italian philosopher, in the year 1643.

How is the barometer constructed?

Take a glass tube about 36 inches long, fill it with mercury, leave it open at one end, then immerse the open end in a cup of mercury; the pressure of the atmosphere on the surface will sustain the mercury in the tube to the height of from 27 to 31 inches.

Why is tube of the barometer left open?

So that the air may press upon it freely

What does the word barometer mean?

Barometer is derived from two Greek words, signifying a measurer of the weight, that is of the atmosphere.

Is the barometer of much importance?

It is, in a scientific point of view, and in the common concerns of life. To the husbandmen it serves as a glass to detect the changes of the weather.

What kind of weather do we have when the air presses the mercury up in the tube?

We have pleasant weather, because the air is of sufficient density to support the clouds.

When the air becomes lighter, what becomes of the mercury?

The mercury sinks in the tube, because the air does not press sufficiently upon the mercury in the bowl; therefore the mercury cannot rise as high in the tube.

When the mercury sinks in the tube, do we have pleasant or stormy weather?

We have stormy weather, because the air is not sufficiently dense to support the clouds.

Is the barometer useful to captains of ships?

It is, as it warns them when to prepare for a storm?

How would a barometer prevent a ship from being destroyed?

The captain would see the mercury sinking in the tube, and thus be enabled to take in sail, and make ready for the storm.

Do you remember of a captain having saved the ship, because he had a barometer?

Dr. Arnott gives the account: He was one of a numerous crew, who probably owed their preservation to the almost miraculous warning of this faithful monitor. He says they were in a southern latitude. The sun had just set with placid appearance, closing a beautiful af-

ternoon. The evening amusements were going on as usual, when suddenly the captain's orders came to prepare with all haste for a storm. The mercury in the barometer had begun to fall with awful rapidity. As yet the oldest sailors could see nothing like a storm in the sky, and were surprised at the greatness and hurry of the preparations; but before everything was quite ready, a hurricane came upon them, more dreadful than the oldest of the sailors had ever known. Nothing could resist its power; the sails were torn to tatters, the masts injured, and at one time the whole rigging was near being destroyed. So loudly for a few hours did the hurricane roar above, the waves around, and the dreadful thunder peal, that no human voice could be heard, and even the speaking trumpet sounded in vain. In that awful night, but for the little tube of mercury which had given the warning, neither the strength of the noble ship, nor the skill and energies of the commander could have availed anything, and not a man would have escaped to tell the tale.

Was it the same kind of barometer as is used on shore?

The marine barometer differs, in having its tube contracted in one place to a very narrow bore, so as to prevent that sudden rising and falling of the mercury which every motion of the ship would else occasion.

To whom else is the barometer of use?



To persons employed about those mines, in which hydrogen gas or fire damp is generated. When the atmosphere becomes unusually light, the hydrogen, being relieved from a part of the pressure which ordinarily confines it to its holes, expands or issues forth to where it may meet the lamp of the miner, and explode, to his destruction. In heavy states of the atmosphere, on the contrary, it is pressed back to its hiding places, and the miner advances with safety.

How can the height of mountains be ascertained by a barometer?

The mercurial column in the barometer is always an exact indication of the weight or pressure of air above its level, therefore the mercury must fall when the instrument is carried from any lower to a higher situation, and the degree of falling must always tell exactly how much air has been left below.

## LECTURE X.

### EFFECTS OF CALORIC.

#### STEAM.

How are we enabled to perform the operation called distilling?

The process of distillation consists simply in evaporating a substance, and again condensing the vapor by causing it to come in contact with a cold surface.

Give an example.

If a mixture of spirits and water be heated up to 110 degrees, the spirits will pass into the aeriform state, leaving the water behind, which may be caught apart and cooled to condensation in any fit receiver.

What do you mean by aeriform

In the form of air.

What is an alembic or still, and what does it resemble?

It is generally made of copper, and somewhat resembles a teakettle.

What kind of a still is most commonly used by chemists?

A retort ; when the vapor which passes over is to be condensed, the beak or mouth of the retort is fitted into a receiver, which may be kept cold by immersion in cold water or in some other way.

Can you give an example of distillation and sublimation ?

Put benzoin upon a hot plate, and place over it a dry flask with a rosebush in it ; and the benzoin will will sublimate upon the rosebush, making it appear as if covered with flakes of snow.

How is steam ordinarily formed ?

Steam is generally formed by ebullition, but it is as dry and invisible as the air itself, until it comes in contact with the air, or other bodies colder than itself, then it becomes water.

Is steam ever applied to practice purposes ?

Steam has been found a useful medium for communicating heat to large buildings. It is also used for heating water baths, dyeing vats and for various culinary purposes. And in cotton and calico manufactories, it is found very advantageous in drying cloth quickly and well.

What are the advantages which it possesses ?

Steam expands in all directions, and conveys heat in any direction—horizontally, upward or downward.

How many methods are used for obviating

power from steam?

There are three methods, condensation, generation and expansion.

What is the most useful application of it?

The propelling of machinery.

What is the instrument called which is employed for the purpose of propelling machinery?

The steam engine.

What is the steam engine?

The steam engine is a machine for producing motion, by the elastic force of steam from boiling water.

What individual made great experiments with the steam engine?

James Watt, who commenced his experiments and inventions about the year 1763.

Where was he born?

James Watt was born at Greenock, in Scotland. He pursued the business of a mathematical instrument maker in London, and was endowed with a mind of a high order, which enabled him to make many important discoveries.

Has the steam engine occupied much attention?

The steam engine has occupied the attention of philosophers for more than a century.

Who planned, built and navigated the first steam vessel?

Robert Fulton, at New York, in the year 1807.

Where was Robert Fulton born ?

Robert Fulton was born at Little Britain, Lancaster County, Pennsylvania, in the year 1765, and the first successful experiment of propelling vessels by steam is due to him ?

When Fulton first made the proposition to propel vessels by steam, what was he considered ?

A fanatic ; but in the midst of all opposition he labored unassisted and alone, and persevered until he had conquered the prejudices, and convinced the understandings of his fellow men.

How had a distinguished poet foretold its success ?

In the following beautiful manner—

“ Soon shall thy arm, unconquered steam ! afar  
Drag the slow barge, or drive the rapid car ;  
Or on wide waving wings expanded bear  
The flying chariots through the fields of air.”

Has the steam engine proved useful in travelling ?

It has ; our communications to foreign countries have been greatly facilitated through the accomplishment of steam navigation.

When did the first steam ship cross the Atlantic ?

In the year 1819, a steamship called the

Savannah, built by Francis Hicket, at New York, and commanded by Commodore Rogers, sailed from thence with the object of making a voyage to England, France and Constradt, which was finally accomplished.

Has the steam engine been of much use to the Americans?

It has become the means which has drawn the most distant parts of the Union together.

Why do steam engines sometimes burst?

Because steam is very elastic, and if this elasticity increases in a greater proportion than the heat which produces it, the steam will burst the vessel unless some vent be allowed

In its present state of perfection, with what does the steam engine seem endowed?

Intelligence; or to use the language of another, "It regulates with perfect accuracy and uniformity, the number of its strokes in a given time; it regulates the quantity of steam admitted to the work, the briskness of the fire: it opens and shuts its valves with absolute precision as to the time and manner; it oils its joints, it takes out any air which may accidentally enter into parts which should be vacuous, and when anything goes wrong which it cannot of itself rectify, it warns its attendants by ringing a bell, yet with all these talents and qualities, and even when exerting the force of hundreds of horses, it is obedient to the hand of a child. Its ailment is coal, wood, and char-

coal, and other combustibles; it consumes none while idle, it never tires, and wants no sleep, it is not subject to malady when originally well made, and only refuses to work when worn out with age; it is equally active in all climates and will do work of any kind, it is a water pumper, a miner, a sailor, a cotton spinner, a weaver, a blacksmith, a miller, and a small engine in the character of a steam pony may be seen dragging after it a hundred tons of merchandize, or a regiment of soldiers, with thrice the speed of our fleetest horse coaches. It is the king of machines, and a permanent realization of eastern fable, submitting natural powers to the command of man.

## LECTURE XI.

### SOURCES OF CALORIC.

What are the principle sources of caloric ?

The sources of caloric may be reduced to six, viz.—the sun, combustion, electricity, chemical, mechanical, and vital action.

What is the great source of light and heat ?

The sun.

Have there been any theories in respect to this ?

Two theories have long prevailed concerning the nature of the sun being the great source of heat.

What did the first class of philosophers believe ?

That the sun was an intensely heated mass, which radiated its heat and light around, like an intensely heated mass of iron.

What is the opinion of the second class of philosophers ?

They hold that heat is merely an affection or state of an ethereal fluid which occupies all spaces, as sound is an affection or motion of the air ; and that the sun may produce the phenomena of light and heat without waste of its temperature or substance, as a bell may produce the phenomena of sound ; holding farther,



that the sun, below its luminous atmosphere, may be habitable even by such animals as live on this earth.

Of what are those who take the first view awakened to a dread contemplation?

Of a universe carrying in itself the seeds of its own decay.

How do the other class view the universe?

The second class views the universe as destined to last nearly unchanged, until a new act of the will of its Creator shall again alter or destroy it.

What is the second source of caloric?

Chemical action.

Is caloric often produced by chemical action?

Caloric is frequently produced by chemical action.

What is combustion?

Combustion has been defined to be the disengagement of light and heat, in substances by chemical action.

What three elements are necessary to produce combustion?

Hydrogen gas, carbon, and oxygen gas.

What does chemistry call forth?

The hidden spirit of combustion.

When a piece of iron wire is lighted as a taper, and dipped in oxygen gas, what effect does it produce?

It burns with great brilliancy.

If certain portions of iron and sulphur be heated together, what effect does it produce?

Vivid combustion.

Of what is every instance of combustion an example?

Of chemical union, going on with such intensity of action as to produce incandescence.

What is the third source of caloric?

Condensation.

What does heavy machinery do if not properly oiled?

Heavy machinery when not properly oiled, frequently ignites the wood.

What does friction in these cases do?

Friction condenses the parts, and the caloric is developed.

What is the fourth source of caloric?

Vital heat.

To what is the caloric developed by vital action supposed to be owing?

The chemical action of the air upon the blood.

Of what does percussion and condensation cause the evolution?

Percussion and condensation cause the evolution of caloric.

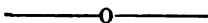
Give an example?

Phosphorus and chlorate of potassa rubbed

together, produce combustion.

What was the theory of Sir Isaac Newton respecting caloric?

Sir Isaac Newton supposed caloric a subtle material fluid, and that each minute indestructible atom of which it is composed is surrounded by alternating concentric hollow spheres of attraction and repulsion; and the admission of caloric does not expand the particles, but the spheres of attraction and repulsion.



## LECTURE XII.

### LIGHT.

What is light?

Light is that principle, or medium by which objects are made preceptible to our sense of seeing, although of its real nature we know nothing.

Does light travel with great rapidity?

The velocity with which light moves is inconceivable, it has been computed by astronomical observations, to be at least one hundred and ninety five thousands of miles in a second of

time ; Herschel says of it that a wink of the eye, or the single motion of the leg of a swift runner, or flap of the wing of the swiftest bird, occupies more time than the passage of a ray of light around the globe.

How many minutes does it take light to travel from the sun to the earth ?

Eight minutes.

Are all bodies luminous ?

All bodies are either luminous, transparent, or opaque : bodies are said to be opaque when they intercept all light, and transparent when they permit it to pass through them.

Do metals ever become luminous ?

Metals become partly transparent when made very thin, as may be seen by gold leaf on a glass, which transmits a greenish-purple light, and in quicksilver, which gives by transmitted light a blue color slightly tinged with purple.

When a ray of light falls upon the surface of a body, what becomes of it ?

When a ray of light falls upon a body, it is either reflected, refracted, or absorbed.

To what is the angle of reflection always equal ?

The angle of reflection is always equal to the angle of incidence.

What is the angle of incidence ?

The angle of incidence is the angle between the line of incidence and the perpendicular.

What is the angle of reflection ?

The angle of reflection is the angle between the line of reflection and the perpendicular.

What are the laws of refraction ?

When the rays of light pass from a rarer to a denser medium, as from air into water, the ray is bent or refracted toward a perpendicular, to that point of the surface on which the light falls ; and from a denser to a rarer medium, the ray is refracted from a perpendicular.

Can you give an experiment in illustration of this law ?

Place a coin in the bottom of a bowl so situated that the observer cannot see the coin until water is poured into the vessel, the coin then becomes visible because the ray of light passing out of the water from the coin is bent toward the eye.

Of how many kinds of rays is solar light composed ?

Three, the calorific, the colorific, and the chemical rays.

What do these rays produce ?

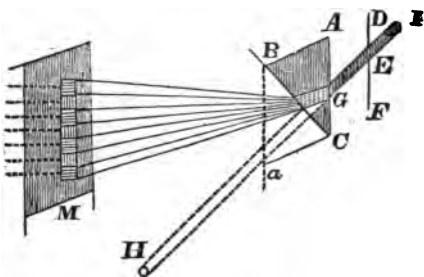
The calorific rays produce heat, the colorific, color, and the chemical, decomposition among substances.

To whom are we indebted for the most important discoveries respecting light and colors ?

Sir Isaac Newton, he was the first person who divided a white ray of light. by means of

a triangular prism, he also found that it contained many colored rays.

Fig. 3.—A triangular prism.



Can you explain the method employed by Newton in the operation ?

Newton's mode of operation consisted in admitting a ray of light  $JG$  (Fig. 3) into a dark room, through an aperture in a window shutter  $DEF$ , and interposing the triangular prism  $ABC$ , so that the ray might pass obliquely through two surfaces, and be refracted by both ; on receiving the refracted ray upon a piece of white paper  $LM$ , there appeared, instead of a spot of white light, an oblong colored surface composed of seven different tints, called the prismatic or solar spectrum. On subjecting each of these colors to refraction, no further separation was accomplished, but on causing the rays separated by one prism to pass through a second of the same power, and in an inverted position  $CBA$ , the seven colors disappeared,

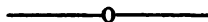
and a spot of white light appeared at  $\pi$ , in the very position it would have occupied had both prisms been absent.

Of how many colors does Dr. Wollaston think the spectrum consists?

Dr. Wollaston supposes the spectrum consists of four colors; red, green, blue, and violet.

What do these different colored rays produce when collected by a lens into a focus?

A colorless light.



## LECTURE XIII.

### THEORIES OF LIGHT.

How many theories have there been respecting the nature of light?

Two, the corpuscular and the undulatory theory.

What was the corpuscular or Nutonian theory?

He thought that luminous bodies were con-

stantly emanating particles of light, and that these particles were material and sent forth in straight lines, in all directions from every luminous body, and falling on the delicate nerves of the eye to produce the sense of vision.

What was the opinion of philosophers respecting the corpuscular theory.

They thought that if it were correct, light must have some weight; in order to determine this, they placed 168 mirrors so as to concentrate all the rays which fell upon them to one point, where there was a scale which was turned by so delicate a weight as 0.03 part of a grain.

What theory has been formed by later writers?

The undulatory theory, which supposes that air is filled with an exceedingly subtile fluid, called ether; that when any luminous body enters this fluid, undulations are formed and these reach our eyes

Does this theory seem to account satisfactorily for all the phenomena which we observe in light?

It does, and this theory also supposes that color is nothing but the different degrees of pressure upon the optic nerve, and that the presence of light is not necessary for us to receive the sensation of color.



What is the instrument called, through which we exercise the sense of vision ?

The eye.

How is it constructed ?

The eye is composed of two membranous coats, the cornea and sclerotica, which together form a globe or ball, and within these coats are contained the iris, the humors of the eye and the retina.

What is the iris ?

It is that colored circle which surrounds the pupil, and it has been so called from its variety of colors in different persons.

Has the iris more than one set of fibres ?

It has two, the circular and radiating, which cross and act in opposition to each other.

When the circular fibres contract, what happens to the pupil ?

The pupil is lessened, and when the radiating fibres, it is enlarged.

What is the pupil ?

It is the opening in the iris, through which the light passes and strikes on the retina.

How many humors are there in the eye ?

Three, the aqueous, crystalline, and vitreous humors.

What is the aqueous humor ?

It is a fluid like water.

What is the crystalline lens.?

The crystalline lens is a transparent body, in the form of a double convex lens, placed between the aqueous and vitreous humors.

What is the retina?

It is the seat of vision, and consists of an expansion of the optic nerve, which is perfectly white.

What is the optic nerve?

It is the organ which carries the impression to the brain.

Fig. 4.—The Eye.



Can you explain figure 4?

Figure 4 represents a front view of the eye, in which *AA* represents the cornea, or as it is commonly called, the white of the eye; *II* is the iris, having a circulating opening in the centre, called the pupil, which contracts in a strong light and expands in a faint one, and thus regulates the quantity which is admitted to the tender parts in the interior of the eye.

Why is the eye pained by a sudden light?

Because the nerve is burdened with rays

before the pupil has had time to contract.

Why can we see nothing when we leave a well lighted room and go into a darker one?

Because the pupil does not dilate instantaneously ; and the contracted pupil is not able to collect rays enough from the dark room to enable us to see objects before us.

Why can we see better after having been in a dark room a few moments?

Because the pupil dilates again, and allows more rays to pass through its aperture.

Why are some persons near sighted?

Because the cornea of their eye is so prominent that the image of distant objects is formed before it reaches the retina, and therefore is not distinctly seen.

Why does the flattening of the cornea prevent persons seeing objects which are near?

Because the cornea is too flat, and the image of near objects is not commonly formed when they reach the retina.

## LECTURE XIV.

### TERRESTRIAL LIGHT.

Does terrestrial light differ from solar?

It does in several respects.

Does artificial light differ from solar?

Artificial light differs from solar in containing heat in two states.

When have some substances the power of absorbing light?

When exposed to luminous bodies; and when placed in the dark they are phosphorescent.

Are there many substances in nature which possess the property of shining in the dark?

There are, the diamond and some other substances, after being exposed to the rays of the sun will emit light for some time in the dark.

By what name are they called?

They are denominated phosphorescent.

What are the leading divisions of these substances?

Solar phosphori, phosphori from heat, and spontaneous phosphori.

What do you mean by solar phosphori?

Those which require a previous exposure to

solar light to become luminous ; such as Canton's, Baldwin's, &c.

How is Canton's phosphorus prepared ?

Calcine common oyster-shells in the fire for an hour ; then select the purest and whitest parts, and reduce them to fine powder : mix three parts of this powder with one of sulphur, and having pressed the mixture into a crucible, keep it red hot for one hour ; then let the crucible cool and select the brightest and purest parts, which, cork up in a dry vial for use. When this composition has been exposed for a few minutes to the light of the sun, and then carried into the dark, it will be sufficiently luminous to show the hour by a watch dial.

Can you give an example of phosphori by heat ?

The yolk of an egg, when dried, becomes luminous on being heated, and so do spermaceti, wax, and tallow, during liquefaction.

Do some animal substances emit light ?

This property is remarkable in some fish, the sea at times presents a magnificent and imposing spectacle.

How have some philosophers explained this phenomena ?

They have shown that on a number of occasions, this light was produced by a little animal called the glow-worm at sea.

Are the zoophytes and molusca phosphorescent ?

They are, in a greater or less degree.

How have some philosophers ascounted for the phosphorescene which is observed at sea?

They are of the opinion that it proceeds from the decomposion of vegetable and animal substances collected together in it, and which in putrefying emit their phosphorus.

Why are putrying fish luminous?

Because the carbon of the fish unites with the oxygen and forms carbonic acid; the phosphoric acid of the fish is converted into phosphorus, which unites with the oxygen of the air, and becomes luminous.

Of what have some persons considered this the origin?

Of those ignes fatui which flutter at night over church-yards and fields of battle.

Why does an ignes fatui fly from us when we pursue it?

Because we produce a current of air in front of ourselves, which drives the light gas from us.

Why does an ignes fatui run after us when we run from it?

Because we produce a current of air, which attracts the light gas in the course we run; drawing it after us in the same volocity we flee from it.

What is the cause of the ignes fatui?

This luminous appearance arises from the

gas of putrifying animal and vegetable substances.

What kind of gas is often combined with phosphorus?

Hydrogen, it is not then fit for respiration, but quickly causes suffocation.

Is it ever necessary to measure light?

It is frequently found necessary to measure light.

What is the instrument called, and how is it constructed?

A photometer, it consists of a very delicate and small differential thermometer, one bulb of which is made of black glass, and the whole is enclosed in a small glass tube. The white ball transmits all the light and heat, and is of course unaffected; the black ball absorbs all the rays, and heats the air within so as to cause the liquid to rise.

What is the process of forming daguerreotype pictures?

Take a piece of silver, or copper plated with silver, well cleaned with nitric acid, and polished with great care with powdered pumice; then expose the plate a few minutes to the action of vapor of iodine, by which an exceedingly thin coating of iodide of silver is formed upon the surface, it is then exposed to the vapor of bromine and then again to iodine. The plate is then placed in a camera obscura, and the image of any object is made to fall upon it

for a few minutes, by which such a chemical change is produced in the thin coating of iodide of silver, that subsequent exposure to the vapor of mercury, at a temperature from  $85^{\circ}$  to  $100^{\circ}$  brings out a beautiful picture.

How is the picture when taken from the mercurial process, rendered permanent?

The picture is rendered permanent by removing the coating of the iodide of silver, which is readily done, by merely pouring over it a warm solution of hyposulphate of soda or common salt.

## LECTURE XV.

### ELECTRICITY.

What is electricity?

Electricity is an invisible, subtle fluid, that appears to pervade all nature. The ancients observed in amber more than 600 years ago a remarkable power of excitation by friction, but modern science has conferred on this power the name of electricity.

From what does it derive its name?



From the Greek word elektron (amber), because the electric property was first discovered in this substance.

How is common electricity excited ?

By the friction of one substance upon another.

Give an example ?

A dry glass tube, rubbed with a silk handkerchief, will attract a pith ball suspended by threads. Resins will also, by similar treatment, become capable of attracting and repelling light substances.

How many kinds of electricity are there ?

Two, the vitreous or positive, and the resinous or negative.

What was the origin of the terms vitreous or resinous ?

The terms vitreous and resinous were adopted, because glass, and other vitreous bodies, when rubbed, generally become positively electrified ; while resinous substances are thus rendered negative.

What is the positive ?

It is that state of a body, which contains more than its due proportions.

What is the negative ?

It is that state of a body which contains less than its due proportions.

What has been supposed by philosophers re-

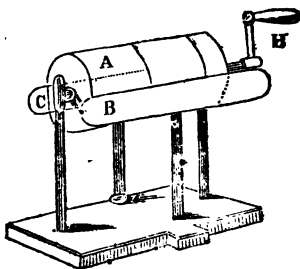
specting electricity?

That every body in nature possesses a certain degree of electric fluid, which may be increased or diminished according to circumstances.

How many kinds of electrical machines are used?

Two, the electrical and plate.

Fig. 5.—Electrical Machine as described in Gray's Chemistry.



Describe the electrical machine?

It consists of a cylinder, or plate of glass A, revolving on an axis, and subjected to the friction of a rubber of leather or silk upon which is spread a thin coat of amalgam, composed of tin and mercury, insulated by a glass pillar, and communicating with the ground by a brass chain. Attached to the machine is a cylindrical metallic conductor which is also insulated by a glass pillar; when the machine is

in operation, vitreous electricity flows from the rubber or glass, by means of fine points, to the prime conductor, and resinous electricity passes in an opposite direction. If the hand be placed upon the conductor, currents of electricity will pass in opposite directions ; but if the hand be held at a little distance from the conductor, a spark will dart through the air and cause a prickling sensation, accompanied by a slight report, with light and heat. The sound is produced by the collapse of the air, as the fluid forces a passage through it ; and the light and heat are supposed to result from the sudden condensation of the air, as in the fire syringe.

## LECTURE XVI.

### ELECTRICITY CONTINUED.

Are all bodies capable of exciting electricity?

They are not.

How are bodies divided ?

Bodies are divided into conductors and non conductors of electricity, or into good and bad conductors.

What are those bodies called which do not convey electricity from one body to another.

Non conductors, and those which do convey fluid from one body to another are denominated conductors.

What is said respecting conductors and non conductors ?

All those bodies which become excited by friction are non conductors for if they conducted freely, the fluid would pass off as quickly as it was excited. They are also called electrics, because they become excited or electrified by friction. Conductors are also called non electrics, because they are not excited by friction ; or, if excited for a moment, have their

equilibrium restored by their conducting power.

What are the principal or good conductors ?

The principal conductors of electricity are gold, silver, brass, iron, &c.

What are bad or imperfect conductors ?

Bad or imperfect conductors are spermaceti, glass, sulphur, fixed oil, oil of turpentine, resin, ice, diamond, and dry gases.

Can electricity be transferred from the machine to the body ?

It can, by standing on a stool supported by glass pillars ; touch the prime conductor with one hand, and sparks may be drawn from any part of the body.

Have there been many experiments performed ?

There have, let several individuals join hands, and indeed a large circle may be formed in this way, then let one of the company touch the tin foil and the whole will feel the shock of it if they keep their hands united.

## LECTURE XVII.

### CAUSES OF ELECTRICAL EXCITEMENT.

Of what is the fire of St. Elma generally considered an accumulation ?

Electric matter around a point which moves in the air.

Where may this fire be expected to appear ?

At the top of the masts of a vessel sailing along with rapidity.

By what name was this phenomena known to the ancients ?

Castor and pollux and many instances have been recorded by classic writers.

Relate an instance as given by Cæsar ?

Cæsar relates that in the month of February during the African war, there suddenly arose a dreadful storm, which threw the Roman army into great confusion, occasioned by the points of the darts of the fifth legion appearing to be on fire.

Relate the instance given by Count Forbin ?

He says that in the night it became extremely dark, and thundered and lightened fearful

ly. We saw upon different parts of the ship about thirty St. Elmo's fires ; among the rest was one upon the top of the vane of the main mast, about eighteen inches long ; I ordered one of the sailors to take the vane down, but he had scarcely removed it, when the fire again appeared upon the top of the mast, where it remained for a long time, and then gradually vanished.

How may a strip of gold leaf be oxidized ?

A strip of gold leaf may be oxidized by pressing it lightly together between two pieces of white paper ; then place it between the knobs of the discharger, so that they may be in contact with its opposite edges. After the discharge the paper will be found stained of a purple color by the oxide of gold which has been formed,

For what are the electrical bells designed ?

The electrical bells are designed to show the effects of electrical attraction and repulsion

Relate the experiment of the thunder house ?

The thunder house is designed to show the security afforded by lightning rods, when lightning strikes a building. A highly combustible material must be placed in the house, and a charge of electricity passed through it ; a surface of tinfoil covers the floor. The hydrogen pistol must be placed on the floor of the thunder house, and connected with the wire on the opposite side. The house must then be put

together, and a chain connected with the wire on the opposite side to the lightning rod, and the other end placed in contact with a single Leyden jar or with the battery. When the jar thus situated is charged, if a connexion be formed between the jar and the points of the lightning rod, the fluid will pass off silently and produce no effect; but if a small brass ball be placed on the points of the rod, and a charge of electricity be sent to it from the jar or the battery, the gas in the pistol will explode, and throw the parts of the house asunder with a loud noise.

What is an electrometer?

The electrometer is made in a variety of forms, on the principle that similar states of electricity repel each other and derives its name from being a measurer of electricity.

Of what does it sometimes consist?

Of a single pith ball attached to a light rod, in the manner of a pendulum, before a graduated arc or circle.

Describe the gold leaf electrometer?

It consists of two leaves of gold, suspended in an air jar, and communicating by a wire with a small plate of brass; the approach to this plate of a body in any degree excited, will occasion an immediate movement of the gold leaves, from which we can tell the nature of the excitement, as above described, having previously imparted to the gold leaves a particular kind of excitement.



## LECTURE XVIII.

### THEORIES OF ELECTRICITY.

What was Franklin's theory respecting electricity ?

Franklin ascribed the phenomena of electricity to the agency of one fluid. He supposed it a highly electric and imponderable fluid, which pervaded all material bodies, and moves through them with various degrees of facility. He supposed bodies to be in their natural state with regard to electricity, when the repulsion of particles of fluid was exactly balanced by the attraction of the matter for the same particles, when they contain a greater quantity than this they were said to be positively electrified.

What was Dufay's theory ?

Dufay supposes that there are two fluids ; the one developed by the friction of the glass he calls vitreous, which answers to the positive electricity of Franklin ; and the other developed by the friction of the wax, he calls resinous, which corresponds with the negative electricity of Franklin. Each fluid repels itself and attracts the other.

What terms describe these conditions?

According to Franklin's theory the two states are denominated positive and negative ; according to Dufay's vitreous and resinous.

What was Faraday's theory?

Faraday supposed that a body was electrified by one fluid, and it induced the opposite kind on those around it.

Describe the Leyden jar.

The Leyden jar was invented by Cunaeus of Leyden, in 1746. It consists of a glass jar, coated inside and out with a piece of tin foil within an inch or two of its upper edge ; a brass rod terminated by a ball, passes through the cork which closes the mouth of the jar, and touches the inside coating.

In what way is it made to receive the electric fluid ?

Present the knob to the prime conductor, and the electric fluid will be conducted down the wire, and distributed over the inner surface of the glass by means of the metallic coating. A large quantity of the fluid can thus be accumulated, so as to give what is called a shock.

What is meant by an electrical battery?

When several Leyden jars are connected by their outer surfaces, and also by their inner ones, they constitute an electrical battery.

Can you relate the experiment of the elec-

trical sportsman ?

From the larger ball of a Leyden jar, two birds made of pith are suspended by a linen thread, silk or hair. When the jar is charged the birds will rise, on account of the repulsion of the fluids in the jar. If the jar be then placed on the tin foil of the stand, and the smaller ball placed within half an inch of the end of the gun, a discharge will be produced and the birds fall.

What is meant by induction ?

Whenever a body positively electrified, is made to approach another in its natural state, it always occasions or induces the contrary or negative state in the latter ; and it is therefore said to be electrified by induction.

How does electrical induction occur ?

Dr. Faraday has shown that the inductive action of ordinary electricity takes place in curves which are analogous to the lines of force surrounding a magnet.

Bodies similarly electrified do what ?

Bodies similarly electrified repel, and those differently electrified attract each other.

How is the experiment of the dancing images conducted ?

By cutting several images in paper, and putting them between two metallic plates ; the upper plate *A* is suspended by a chain from the prime conductor to the machine ; the lower

plate B is connected with the ground. When the machine is turned, the images are attracted to the upper plate ; but if they come in contact with it they are repelled, and fall ; but when they strike the lower plate, their electricity is discharged, and they are again attracted to the upper plate as before. They are thus made to dance about as currents of air may happen to move them, and thus form a very amusing experiment.

Fig. 6.



## LECTURE XIX.

### LAWS OF ELECTRICITY AND LIGHTNING.

Who discovered the laws of electricity?

Dr. Franklin, a self-taught philosopher was bold enough to make an experiment on the clouds and draw lightning from the sky.

Under what circumstance swas the discovery of lightning and electricity made?

In the year 1752 Dr. Franklin was waiting for the erection of a spire of a church on which he intended to erect a pointed metal rod, with a view of withdrawing the electricity from the clouds; when the accidental sight of a boy's kite suggested to him that ready means of obtaining access to the more elevated regions of the air. He stretched a silk handkerchief over a light wooden cross, and arranged it as a kite to this he attached a hempen string terminating in a silk cord, and taking advantage of a thunder storm, raised it in the air, when, after a while, he succeeded in obtaining sparks from a key attached to the lower end of the hempen string of the kite.

What has Franklin been considered?

"A playmate of the lightning."

Did any person repeat the experiment?

Romer, in France obtained the most brilliant and astonishing results, he made use of a kite eleven feet high and three wide.

Are such experiments dangerous?

They are, if very great precaution is not used.

Has any person ever been known to lose his life in this way?

Professor Richmann of St. Petersburg was killed by lightning, on the 6th day of August 1753.

Can you relate the circumstances?

Professor Richmann had erected upon the top of his house, an iron rod, from which proceeded a chain that entered his study. The whole apparatus was entirely insulated. He was examining the electrometer as a thunder storm was approaching; a large globe of blue fire flashed from the conductor to his head instantly depriving him of life.

Upon what does the efficacy of lightning conductors depend?

On the power of a point to draw away insensibly very powerful charges of electricity; it is also essential that they should be insulated, and that the lower end should enter so deep into the earth as always to be in damp ground.

In thunder storms, where does the electric fluid generally pass?

The electric fluid sometimes passes from the clouds to the earth, and from the earth to the clouds.

What causes the discharge of an electric cloud ?

A cloud overcharged with electric fluid approaches one not charged, the fluid rushes from the former into the latter, till both contain an equal quantity,

How high are lightning clouds from the earth ?

They are frequently elevated 4 or 5 miles high, but they are seldom discharged in a thunder storm, when they are more than seven hundred yards above the surface of the earth.

Is it unsafe to take shelter under a tree during a thunder storm ?

It is because the tree attracts the fluid, and the human body being a better conductor than the tree, the fluid leaves it, and passes through the body.

Would it be safe to stand, during a storm, 20 or 30 feet from a tall tree ?

It would because the lightning would always choose the tall tree as a conductor.

## LECTURE XX.

### LIGHTNING AND ITS EFFECTS.

What constitutes lightning?

Lightning is accumulated electricity, discharged in the form of a flash.

Into how many kinds has it been divided?

Arago divided lightning into three kinds, zigzag, sheet, and ball.

What do you mean by zigzag lightning?

Zigzag lightning derives its name from the peculiarity of its figure.

What is its appearance?

Zigzag lightning appears as a narrow jagged line of intensely vivid light, traversing space with great velocity. On account of the unequal conducting power of different portions of the atmosphere, the flash sometimes divides, branching out in several different directions, the lightning is then forked.

What is sheet lightning?

Sheet lightning is either the reflection of distant flashes not distinctly visible, or several flashes intermingled, it is the most common and



appears during a storm illuminating the edges of the clouds.

What is ball lightning?

Lightning occasionally assumes the globular form, which is the most dangerous,

Why are these balls of fire dangerous?

Balls of fire are dangerous because when they fall, they explode like a cannon.

What mischief do these balls of fire produce?

They set fire to houses and destroy everything in their course.

Relate an instance as described by Brocklesby in his Meteorology.

In a storm that happened at Steeple Aston, Wiltshire, in 1772, the Rev. Messrs. Pitcairne and Waithouse, while in the vestry of the Church, saw suddenly before them, at the distance of a foot, and at about their own height from the floor, a ball of fire, nearly the size of a man's fist, surrounded by black smoke. It burst with an explosion like the discharge of several cannon. Pitcairn was dangerously wounded, and his person and clothes showed the usual marks of lightning. During a thunder storm that occurred in 1809, at Newcastle-upon-Tyne, the house of David Sutton was struck, the lightning descended the chimney; after the explosion, several persons who were assembled in a room, saw at the door a globe of fire, which, having remained stationary for

some time, advanced into the middle of the room, where it burst into fragments, with a report like a rocket.

Can you relate another instance?

On the fourth of November, 1749, in  $42^{\circ} 48'$  N. lat.,  $2^{\circ}$  W. lon., the crew of the ship *Montague* beheld, a little before noon, and beneath an unclouded sky, a globe of bluish fire, like a millstone rolling rapidly along the sea; at a short distance from the vessel, it rose perpendicularly from the water, and struck the masts with an explosion louder than the discharge of a hundred canon. Five Sailors were thrown senseless on the deck, one of whom was severely burned.

Why is lightning more common in summer and autumn, than in spring and winter?

The heat of summer and autumn produces greater evaporation than in spring or winter.

What is heat lightning?

We denominate that heat lightning which we witness in the serene evenings of summer.

## LECTURE XXI.

### GALVANISM.

From what does galvanism derive its name?

Galvanism derives its name and owes its origin to the experiments of Galvani who was professor of anatomy in the university at Bologna, Italy, in the year 1790.

By what means did he discover this science?

He was engaged in a series of experiments, with a view to prove that muscular action was intimately connected with electrical. He observed that when a piece of zinc was placed in contact with the nerves of a frog, and a piece of copper with the muscles, the animal would be violently convulsed.

To what did he attribute this?

Galvani supposed the nervous fluid to be analogous to electricity, discharging itself from the muscles, in consequence of the conducting power of the metals.

How is the galvanic influence excited?

If a person place a piece of one metal, a

twenty five cent piece, above his tongue, and a piece of zinc below, he will perceive a peculiar taste ; and in the dark, will see a flash of light, whenever the outer edges of the metals are in contact.

Who afterwards showed the fallacy of Galvani's theory ?

Volta, professor of natural philosophy at Pavia.

How did he prove it ?

Volta proved by experiment that electricity is excited by the contact of the metals and that the convulsion was owing to the current passing through the conducting muscles and nerves.

Who was the first that contrived an apparatus for exciting electricity in this way ?

Volta was the first that contrived the Voltaic apparatus, known by the name of the Voltaic pile.

How was it constructed ?

The voltaic pile consisted of a great number of pairs of zinc and copper, with a layer of cloth interposed between them, and moistened by a solution of salt.

What was essential in the voltaic pile ?

That the order of succession should be preserved.

What instrument is used in preference ?

The galvanic battery.

How is it constructed ?

It is composed of two cylinders of copper and one of zinc, moistened with diluted acid ; the zinc oxidates with the greatest degree of rapidity.

How was Cruikshank's trough (commonly called the electrical battery ) constructed ?

Cruikshank's trough consists of a trough of dry wood, divided into cells by partitions placed at equal distances ; each partition is made of a plate of zinc and a plate of copper previously soldered together, and fitted into a groove cut into the wood : the cells between the plates are to be nearly filled with water, having some nitric or other acid mixed with it.

How is the couronne des tasses described ?

The couronne des tasses consists of a row of common tumblers or glasses, containing salt and water, or a saline fluid. Each glass contains a pair of plates ; and each zinc plate is attached to the copper of the next by a metallic wire, which is soldered to the plates.

By what other name has the couronne des tasses been called ?

In its literal application it means the crown of cups.

What has Dr. Hare's battery been called ?

The battery of Dr. Hare has been called a deflagrator.

What is the principle upon which the pile and galvanic battery were constructed?

That metals which oxydate with different degrees of rapidity, will, when immersed in diluted acid, cause the evolution of electric fluid.

When electric currents are caused to pass around soft iron bars, how do they become?

The bars become magnetic and lose their power when the current ceases.

## LECTURE XXII.

### EFFECTS OF GALVANISM.

What are some of the igniting effects of galvanism?

When the battery is in action, if two poles are connected by a small wire, it will become so heated, and give out light so vivid, that the eye can scarcely endure it.

What effects may be produced by a spark

from a voltaic battery?

The spark from a powerful voltaic battery acts upon and inflames gunpowder, charcoal, cotton, and other inflammable bodies, fuses all metals, burns up or disperses diamonds, and other substances on which heat in other forms produces little or no effect.

Can brilliant combustion be exhibited when placed on mercury, by means of the battery?

Take a dish, put a quantity of mercury in it, then connect it with the negative pole of a strong battery; whatever is to be subjected to experiment, attach to the positive wire, and make it touch the surface of the mercury; fine iron wire burns in this manner with great rapidity, giving off vivid sparks and producing an appearance like that of a brilliant star.

Does the color of light vary in different metals?

It does, gold leaf burns with a white light tinged with blue, and yields a dark brown oxide; silver emits an emerald green light of great brilliancy; copper, a bluish white light with red sparks; lead, a beautiful purple; and zinc, a brilliant white light, tinged with blue and red.

In what was the chemical effects of galvanism first noticed?

In the decomposition of oxygen and hydrogen. When two gold or platinum wires are connected with the opposite poles of a battery,

and their free ends plunged in the same cup of water, but without touching each other, oxygen gas is discharged at the positive wire, and hydrogen gas at the negative.

Can these gases be collected ?

These gases, when collected, will be found to consist of oxygen and hydrogen mixed in precisely the proportions for forming water.

How is the instrument formed for collecting these gases ?

This little instrument consists of a bent glass tube ; through the two corks platinum wires are passed, extending through the whole length of their tubes, and almost meeting each other at the angle : each leg of the instrument is corked air-tight, but at the bend is a small hole through the lower side of the tube. If this instrument be immersed in a vessel of water, and each of the wires connected with one of the poles of the galvanic battery, the two portions of the tube will be found to contain gas ; that in the positive part will be oxygen ; in the negative, hydrogen ; and the hydrogen will be in bulk, twice that of the oxygen.

Can this experiment be made to succeed, if two straight tubes, open at their lower end, are immersed in separate vessels of water ?

The experiment succeeds equally well if the conducting wires are plunged into separate vessels or glass cups of water, and made to communicate with each other by moistened fi-



bres of cotton. This important discovery led to similar trials upon other substances.

Can acids, salts, and alkalies be subjected to galvanic agency?

Acids, salts, and alkalies were decomposed through the agency of galvanism; one of their elements appearing at the positive, the other at the negative pole.

Can dry alkali, or an alkaline earth, be excited positively by contact with a metal?

They can, dry acids, after having touched a metal, are negative, and the contact of acids and alkalies, when dry, render the former negative and the latter positive.

By whom were these singular results first obtained?

By Sir. H. Davy who made many useful applications of his theory. Thus, copper is rapidly corroded in acid, or saline solutions; but in contact with zinc, iron, and some other metals, copper becomes electro-negative, and remains bright, while the other metal becomes rapidly deoxidized.

Have galvanic experiments ever been performed on dead bodies?

Galvanic experiments have frequently been performed in dissecting rooms. Sometimes after galvanism has been applied the subject has opened its eyes, and stared wildly around as if sensible of what was going on.

How many theories have been constructed

to account for the phenomena of the galvanic pile?

Three, by Volta, Dr. Wollaston, and Sir. H. Davy.

With whom did the electrical or first theory originate?

Volta, who maintained that the electricity was set in motion and kept up solely by the contact of the metals.

What is the chemical theory of Dr. Wollaston?

The chemical theory, by Dr. Wollaston is so called because it regards the chemical action which goes on in the pile, viz:—the oxydation of the zinc; he was led to conclude that the process commences with the oxydation of the zinc, and that the oxydation is the primary cause of the developement of electricity.

What does the electro-chemical theory of Davy suppose?

The electro-chemical theory of Davy supposes that the electric equilibrium is first disturbed by the contact of the zinc and copper plates, and that the excitement is afterwards kept up and increased by the chemical action between the liquid and the metal.



## LECTURE XXIII.

### MAGNETISM.

What is magnetism ?

Magnetism is the name given to the unknown principle in some kinds of iron, which endows them with the power of attracting other pieces of iron ; there appears to exist a substance or force of some kind or other, which exercises an influence probably over all terrestrial bodies, but which is chiefly shown as it acts upon the ore of oxydated iron, called loadstone.

How many kinds of magnets are there ?

There are two the natural and the artificial.

What is the natural magnet ?

The loadstone which is an ore of iron, found in iron mines, and has the property of attracting to itself small particles of iron.

What may the earth be considered ?

As a great natural magnet, which, by its action on the needle, in the same manner as any other magnet, causes it to place itself in the position of north and south,

Are there any magnetic masses of iron in this state?

There are.

Do all magnetic stones possess magnetic properties?

They do, nickel and cobalt besides many fragments of iron ore, in which oxydation has taken place, possess this property.

Describe a magnetic needle.

A magnetic needle is a light magnetic bar, so arranged that it can be poised on a pivot with freedom of motion.

What is meant by polarity? *Quantity of pointing to the pole*

The needle possesses polarity, or points north and south, a fact of the utmost importance in navigation.

What is the law of magnetic attractions and repulsions?

When to a needle the poles of a bar are approached, it exhibits attractive and repulsive movements. The law under which these take place, is "Like poles repel, and unlike ones attract; two north or south poles repel, but a north and south attract."

How are magnets formed?

Magnets are made of all forms, but the most common method is the so called horse shoe magnet.

What is a horse shoe magnet?

When the two poles of a magnet are brought

together in the form of a horse shoe, or the letter U, it is denominated a horse shoe magnet.

If a magnet is broken, what effect is produced?

It becomes two perfect magnets.

What effect has heat on the power of a magnet?

It weakens it, and a great degree of heat destroys its power.

Where are the north and south poles of a magnet the most powerful?

The north pole of a magnet is the most powerful north of the equator; the south pole, south of the equator.

How may bars of hardened iron be magnetised?

By bringing them in contact with a magnet.

If the iron be extremely hard or exceedingly soft with what does it part?

Its magnetism.

How many poles do magnetised bars present?

Two, which are called the positive and negative.

What idea did Ampère suggest?

Ampère suggested the idea that there are two currents of electricity passing around all those bars that are magnetic.

Through what do the poles of a magnet ex-

ert their power ?

A vacuum, air, and solids.

Where is the magnet used ?

At sea ; it always points to the north, and is convenient for determining directions, latitude, and longitude.

What is the theory that accounts for the variation of the mariner's compass ?

The theory supposes a large mass of melted magnetic iron, revolving round the north pole, from west to east, and that this attracts the needle.

How often is it supposed to move around the pole ?

Once in 666 years.

What is the magnetic meridian ?

The magnetic meridian is a curved line going around the earth, in which line the magnet points directly north.

What did Sir Humphrey Davy suppose ?

Sir Humphrey Davy supposed that the atoms of all substances which unite, are in opposite states of electricity.

What has been noticed when a ship was struck with lightning ?

That the magnetic needle often had its poles destroyed or reversed, and that the iron often becomes magnetic.

How are artificial magnets made ?

By applying one or more powerful magnets to pieces of soft iron.

## LECTURE XXIV

### ELECTRO MAGNETISM.

Who discovered electro magnetism?

Professor Oersted of Copenhagen, in 1819, first made known the laws of electro magnetic attraction and repulsion.

Of what does electro magnetism treat?

Electro magnetism relates to magnetism which is induced by the agency of electricity.

How can magnetism be communicated to iron and steel?

Magnetism may be communicated to iron and steel by means of an electrical machine, or the voltaic battery. This phenomenon is called electro magnetic induction.

Can you give an example of inductive magnetism?

The magnetic bar will hold a large key, this can hold a second smaller than itself, this, a nail; the nail, a tack nail, and lastly a few iron filings are held by the tack nail; and the whole receive their magnetism by induction

from the bar, and each article has its own separate polarity.

What is the theory of Ampere in relation to the magnet?

Ampere supposes that magnets are only masses of matter, around the axis of which electrical currents are moving in closed curves.

Has the theory of Ampere been found a safe guide in experiment?

It has, and many of the most interesting facts of the science are the direct consequences of it.

What is the helix?

A wire, coiled, made the medium of communication, becomes capable of manifesting very strong magnetic influence on any conductor placed in its axis; if a delicate steel needle is laid in the helix, the magnetism it thus receives will be retained by it; but if it be of soft iron, it is a magnet only while the current is passing. Brass, lead, copper, or any other metallic conductor can in this way be made to manifest temporary magnetic power.

By whom was the rapid passage of an electrical current over a metallic conductor discovered?

The inconceivably rapid passage of an electrical current over a metallic conductor was discovered by Watson in 1747, and this gave the first hint of the possibility of using elec-



tricity as a means of telegraphic communication. Shortly after this various attempts were made to construct a telegraph to be worked by ordinary electricity, but these attempts were only attended by partial success.

Who brought it in successful operation ?

The discovery of electro magnetism by Ersted, in 1820, supplied the necessary means of successful construction. But superior to all contrivances, is the beautiful one patented by Professor F. B. Morse, of New York, in 1837, since which time it has been in successful operation, wires having been put up in most of the principle cities in the United States.

What is the electro magnetic telegraph ?

It is an instrument used to communicate intelligence from one place to another. Two stations are taken at some distance apart ; at one of the stations is the battery, with wires extending to the other station, and connected with a magnetic needle, in such a way, that when the wires are attached to the battery, a motion is produced in the needle, to which is attached a pencil, to mark certain characters, which are agreed upon as symbols of ideas. Let us suppose that a communication is to be made between two places, at a distance from each other, as from Albany to Buffalo ; the telegraph is in Albany, and the galvanic battery which puts it in action, is in Buffalo ; the two wires being perfectly insulated, and extending quite from

one to the other. The operator in Buffalo first gives a signal to the one in Albany, who immediately puts the clock work of the telegraph in motion, by which the paper is carried slowly forward ; the operator in Buffalo, then, by closing and breaking the circuit at the battery causes the telegraph to write what he pleases, the alphabet being perfectly intelligible to both operators. Thus a means of communication is established between the two places, by which intelligence may be transmitted quick as thought.

Can you give an instance of its practical utility ?

One of the daily papers thus spoke of its utility. "A few days since, a gentleman residing in the upper part of the city of New York, received a message by telegraph, summoning him to the bedside of a dying relative in Philadelphia. The dispatch was brought to him at a quarter past four o'clock, and at half past four he was on his way thither. Early the next morning he communicated to his family, by the telegraph, the news of the death of his relative, and other items ; and in the afternoon he ascertained by the same means, whether any of his friends residing in the city, could attend the funeral."

How is the telegraph auxiliary to astronomy ?

The telegraph has become very important in

astronomical observations, by furnishing an exact means of determining longitudes. For this purpose the principal astronomical observations in the United States are connected by telegraphic wires, and such is the velocity of the electrical wave that any communication made at one station will be received at all others, at almost the same instant. The telegraph has been made to regulate time pieces, and for signaling fires.

What is one of the most beautiful applications of the laws of magnetism?

The construction of masks of magnetised steel wire, which are now employed by the workmen who are engaged in the pointing of needles.

Was this occupation formerly attended with great hazard?

It was, the workmen being obliged to breathe in an atmosphere filled with fine particles of steel, which fly from the grindstone used in pointing the needles; the irritation produced by this dust caused disease of the lungs, which often terminated in consumption. Various experiments were resorted to in order to exclude this fine penetrating dust, but none proved effectual until the magnetic influence was resorted to. Masks of magnetised steel were then made for the workmen, who, by their instrumentality were enabled to breathe freely, as the floating atoms of steel would be repelled from

the mask.

Having now concluded the study of the imponderable agents, do you not think that they may be regarded as mysterious.

While persuing the study of the imponderables, the mind cannot but regard them as mysterious agents, and thus revert from nature's works to Him who upholds and preserves the harmony of the universe

*Begin*

**PART II.**  
**CHEMICAL ATTRACTION.**

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**LECTURE I.**

**AFFINITY.**

To what are all chemical phenomena owing?

Chemical attraction or affinity.

What is meant by the term affinity?

When we speak of affinity, we mean the tendency which bodies have to unite with each other.

Is the subject of affinity an important part of chemistry?

It is the basis on which the science is founded, and is, as it were, the instrument which the chemist employs in all his operations, it is exerted between the minutest particles of different kinds of matter, causing them to combine, so as to form new bodies, endowed with new properties.

How is affinity divided?

It is divided into two kinds, remote and contiguous, or simple and elective affinity.

What is remote affinity?

It is that which acts at sensible distances.

What is contiguous affinity?

It is that which acts at insensible distances.

Into how many classes is contiguous affinity divided?

Contiguous affinity is divided into two classes, homogeneous and heterogeneous affinity.

What is homogenous affinity?

Homogenous affinity is that which acts upon substances in nature which are alike, as the particles in a mass of lead or iron.

What is heterogenous affinity?

It is that kind which acts upon unlike substances.

Do we know anything of affinity?

Our knowledge of affinity is confined to facts proved by experiment.

Are all substances subject to the laws of affinity?

They are not.

Give an example of elective affinity.

Oil and water will not of themselves combine, but if a third substance be added which has an attraction for both, as caustic potash, the result will be a union of the three, called soap.

Give another example.

Pour water into a solution of alcohol and camphor. The alcohol has a stronger affinity for the water than for the camphor ; it consequently leaves the camphor and unites with the water.

How many substances are present in the case of single elective affinity ?

Three substances only are present ; and two affinities are in play.

How may the fact be proved, that some substances have a stronger affinity than others.

By pouring muriatic acid upon carbonate of soda ; the soda having a stronger affinity for the muriatic acid than for the carbon, unites with it and the carbonic acid is driven off in the form of gas.

## LECTURE II.

### EFFECTS OF AFFINITY.

Do circumstances modify affinity?

The circumstances which modify the action of affinity are numerous.

When substances are finely powdered do they unite with other substances more readily than coarse grains?

They do, if sulphuric acid is applied to powdered chalk, it combines much more rapidly than when applied to coarse grains.

Can the effects of affinity be modified by change of temperature?

It can, if chlorate of potassa and turpentine are poured upon brown sugar, which is a compound of carbon, oxygen, and hydrogen, it will not burn; but if a little sulphuric acid be added, it will instantly ignite.

Do you remember another example?

If a few grains of chlorate of potassa and phosphorus be put under water, and sulphuric acid be added, it will decompose the chlorate of potassa, and the chlorine will unite with the phosphorus, and produce combustion.

If sulphuric acid and water are mixed in a



glass which has a piece of phosphorus upon the outside, what will be the result.

The affinity between the sulphuric acid and water, will, if a sufficient quantity of heat is generated, cause the phosphorus to burn.

Does affinity change color?

It does, a solution of red cabbage, which contains a little sulphuric acid, will become green if ammonia be added.

If sulphuric acid be added, of what color will it become?

It will resume its former redness and if ammonia be added to sulphate of copper, it becomes a bright blue.

Does affinity change the form?

It does, for instance, if a saturated solution of muriate of lime in water be mixed with a small quantity of sulphuric acid, the two fluids will immediately become a solid.

What forms gunpowder?

Sulphur, nitre, and charcoal, form gunpowder.

What is the result if they become heated?

They will explode and pass off in the form of gas,

If spirits of turpentine, chlorate of potassa, and sulphuric acid are united, what effect will be produced?

They will blaze, and become gas.

Does affinity change the specific gravity.

It does, mix one hundred measures of strong sulphuric acid with one hundred of water, and the mixture will be less than two hundred measures.

Does affinity change the temperature ?

It does, wet a piece of paper with spirits of turpentine and sulphuric acid, and then throw on a few grains of chlorate of potassa ; the paper will be instantly in flames.

## LECTURE III.

### LAWS OF CHEMICAL AFFINITY.

What are the laws of chemical affinity?

Most substances have been found to combine in definite proportions, and with such, the laws of affinity are chiefly concerned.

How do some substances unite?

Some substances unite in indefinite proportions, thus, a drop of water will combine with a quart of water.

Do all substances unite in the same proportions?

They do not, they combine in all proportions as far as a certain point, beyond which combination no longer takes place.

Give an example.

Thus, water will take up successive portions of salt, until at length it becomes incapable of dissolving any more.

What is the law of definite proportions by weight?

The proportions in which bodies are disposed to unite with each other, can always be represented by certain numbers, these numbers

being the relative weight of their atoms: thus, water is composed of an atom of oxygen and one of hydrogen; and inasmuch as the oxygen atom is eight times heavier than that of the hydrogen, it necessarily follows that in every nine parts of water, we shall have eight of oxygen and one of hydrogen.

Of what does the atomic theory suppose matter to be composed?

The atomic theory supposes matter to be composed of minute indivisible atoms.

On what supposition does this theory proceed?

This theory proceeds upon the supposition that all bodies are an assemblage of mixed individual atoms, and that these atoms differ in weight.

By what terms are the weight of atoms designated?

The weight of atoms are designated by the terms equivalents, combining proportions, &c.

What has been ascertained by experiment in regard to them?

That one atom of oxygen weighs eight times as much as one of hydrogen, and that they unite in the proportions of one to eight.

How much heavier is an atom of sulphur than one of hydrogen?

An atom of sulphur is sixteen times heavier than an atom of hydrogen.

In what proportions do they unite ?

In the proportion of 16 to 1.

Is there any other law for the union of atoms ?

They also unite in proportion to their volumes.

Give an example.

An atom of hydrogen occupies twice the space of an atom of oxygen. Thus a gallon of oxygen would require two gallons of hydrogen to form water ; and if they be weighed, it will be found that it is in exact proportion of 8 to 1.

What has the atomic theory been considered ?

The atomic theory has by some been considered an elegant and probable hypothesis, displaying uncommon ingenuity and great chemical research.

What does homogeneous affinity produce ?

It produces aggregation, giving rise sometimes to regular and sometimes irregular forms.

## LECTURE IV.

### CRYSTALLOGRAPHY.

What is crystallization?

The power which determines the forms of inorganic matter is called crystallization.

Do the same substances always assume the same form when they crystallize.

Every solid that is susceptible of crystallization has a tendency to assume a particular shape ; thus, common salt when most perfectly crystallized, forms regular cubes ; nitre has the shape of a six sided prism ; alum, that of an octahedron ; while carbonate of lime produces a regular rhomboid.

What is a crystal ?

A crystal is the geometrical form possessed by a vast number of mineral and saline substances, whose particles combine with each other by the attraction of cohesion, according to certain laws.

What circumstances influence crystallization ?

Solution is one of the most important condi-

tions necessary to crystallization. A saturated hot solution will usually deposit crystals on cooling—common alum is an example of this; sulphur crystallizes on cooling from fusion, and so do bismuth and some other substances.

Does the mineral kingdom present any form of crystals?

It does, some of the most splendid examples of crystals are found in the mineral kingdom,

What are sides of crystals called?

The sides of crystals are called planes.

Can the angles of crystals be measured?

The angles of crystals are measured by means of instruments called goniometer, the name of which is derived from two Greek words gonia, an angle, and metron, measure.

What is a goniometer?

A goniometer consists of a light semicircle of brass, accurately graduated into degrees, and having a pair of steel arms moving on a central point, and so arranged as to slip in a groove over each other.

How many primary forms of crystals are there?

Seven, the cube, tetrahedron, octahedron, prism, rhombic, dodecahedron, isoscles triangular dodecahedron, and rhomb.

What is a cube?

A cube is a solid, having six equal square sides.

What is a tetrahedron ?

A tetrahedron is a solid, bounded by four equilateral triangles.

What is a prism ?

A prism is a solid, the sides of which are parallelograms, and the terminal planes are equal and similar figures.

What is a rhombic dodecahedron ?

A rhombic dodecahedron is a solid bounded by twelve rhombic faces.

What is an isosceles triangular dodecahedron ?

An isosceles triangular dodecahedron is a solid, bounded by twelve isosceles triangular faces.

What is a rhomb ?

A rhomb is a solid bounded by six rhombic faces.

On what does the form of crystals depend ?

The form of crystals depend upon their chemical constitution.

To what number may the primary form of crystals be reduced ?

By mechanical division they may be reduced to three.

What are their names ?

Tetrahedron, triangular prism, and rhomb.



## LECTURE V.

### CRYSTALLOGRAPHY CONTINUED.

By what name is the carbonate of lime often called when combined with carbonic acid?

It is frequently called calcareous spar.

Is it ever used as a building material?

Calcareous spar forms the ordinary building material in France.

By what name is it called when it crystallizes with a fine grain?

Marble or calcareous free stone.

Which marble is esteemed the purest?

The white statuary marble, from Carrara, in Italy.

Of what are the colored marbles formed?

Of calcareous matter, mixed with extraneous substances.

Does every country abound with marble?

Pliny says that every country possesses its peculiar species of marble.

Where are crystals of carbonated lime, under the name of calcareous spar, found?

In almost every subterraneous cavity, and in all veins.

For what do they serve as ornaments ?

For cabinets of mineralogy.

What varieties do phosphated and fluated lime exhibit ?

Colored crystals, which resemble the precious stones, such as selenites, emeralds, rubies, and others.

What is sulphate of lime commonly called ?

Sulphate of lime is commonly known by the name of gypsum.

Is gypsum a mineral ?

It is a mineral which is frequently found in nature, and in some localities it forms entire ranges of hills ; it is also known by the name of plaster of Paris.

Are there many varieties of gypsum ?

There are.

For what is gypsum extensively used ?

For plastering rooms, stucco work, casts of statues, architectural models, and it is indispensable in stereotyping.

Is it ever used by the agriculturist ?

Gypsum is extensively used by the agriculturist in fertilizing the soil, it has a beneficial effect upon the growth of plants, as it absorbs the carbonate of ammonia contained in the air and in rain water, and fixes it in the soil, and these two salts are converted into sulphate of ammonia and carbonate of lime.

When crystalized what is it called ?

It is then known by the name of selenite, which can be divided into brilliant and transparent laminæ.

How was selenite used by the ancients ?

In the place of glass, for windows.

Can the crystallization of substances be effected by more than one process ?

It can, by various processes.

Give an example.

If a quantity of sulphur is melted and allowed to cool slowly, then break the crust, and pour out what remains a liquid, a mass of crystals will be found shooting in every direction.

Does crystallization ever take place in solids ?

It does, common wire, when kept a long time, loses its tenacity, in consequence of cubic crystals of the metal gradually forming in it.

## LECTURE VI

### NOMENCLATURE OF CHEMISTRY.

By what has the study of particular substances been greatly facilitated?

By the introduction of the nomenclature.

When, and by whom was it introduced?

In the year 1787, by the French chemists.

What is the principle upon which the nomenclature is founded?

When bodies unite with oxygen, two sets of compounds are produced, differing in many respects from each other; the one called oxides or salifiable principles; the other, acids or salifying principles.

In what do the oxides differ from the acids?

In the want of the sour taste which generally belongs to the latter, and in their not changing vegetable blue colors to red; but they are better characterized by the fact that they combine with acids and form bodies which are termed salts.

Have the names of the elementary substan-

ces which have long been known, remained unaltered?

They have.

When oxygen unites with an acidifiable substance, what is the product?

An acid.

When oxygen unites with a metal, what is the compound called?

An oxide.

If there is one proportion of oxygen, what is the compound?

When there is one proportion of oxygen the compound is termed a protoxide; if two, a deutoxide; if three, a tritoxide; and four or more, a peroxide.

How many terminations have acids?

Two, ic and ous.

When the acidifiable base is united to the highest proportion of the acidifying principle in what does the termination end?

Ic; when the lower, ous.

By what are the higher and lower proportions of the acidifying principle sometimes indicated?

The prefixes hyper for above, and hypo for below.

When a salt is composed of a base united with an acid in its highest state of acidification in what does the name of the acid end?

Ate.

If the acid is in the lowest state of acidification, in what does the name of the acid end?

Ite.

When an acidifiable substance is united to a base, without being acidified, in what does its termination end?

Uret.

When the compounds are both acidifiable substances, not metallic, but in a state of gas, in what does the termination most generally end?

Uretted.

What is the compound called when two or more metals are combined?

An alloy.

By what name is it called when one of the metals is mercury?

An amalgam.

AFFINITY.

PART III.

INORGANIC CHEMISTRY.

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LECTURE I.

NON METALLIC AGENTS.—OXYGEN.

Into what are the ponderable agents, or elementary principles divided?

Into non metallic and metallic elements.

Which is the first of the non metallic agents?

Oxygen.

What is oxygen?

Oxygen is a gaseous body, which is found largely diffused throughout all nature.

By whom was it discovered?

Oxygen was discovered in 1774, by Dr. Priestly of England. And Scheele of Sweden, discovered it in 1795, and the same year Lavoisier of Paris; independent of each other.

By what name did Dr. Priestly call it?

He gave it the name of dephlogisticated air, Scheele, empyreal air; and Condorcet, vital air.

Why did he call it vital air ?

Because it is a supporter of animal life.

From whom did it receive the name of oxygen ?

Lavoisier.

From what is the name oxygen derived ?

From two Greek words, which signify a generator of acids.

What are some of the properties of oxygen ?

Oxygen when pure, is a transparent, inodorous, and tasteless gas ; it is a supporter of respiration and animal life ; none can do without it ; it exists in nature in three states, solid, liquid and gas.

When combined with iron, what is it called ?

Iron rust.

How can oxygen be obtained ?

Oxygen may be obtained by applying heat to the black peroxide of manganese. It may also be obtained by applying heat to chlorate of potassa, this is much purer but more expensive.

Is oxygen one of the elements of air ?

It is ; the atmosphere consists of 78 parts of nitrogen, 21 of oxygen. and 1 of carbonic acid or fixed air.

Can you relate an instance of the persons who were confined in the hole at Calcutta ?



A few years since, 148 persons were confined in a prison 18 feet square, and 15 or 16 feet high, called black hole in Calcutta, for a single night. There were only two very small windows in one side of the prison, by which air could be admitted ; and in the morning when the hole was opened, only twenty three were found alive : the oxygen during the night had become exhausted, and the atmosphere overcharged with carbonic acid and thus caused their death.

What frequently causes persons to faint when in a crowded room ?

When the oxygen becomes nearly exhausted, and the air impure and vitiated ; giddiness, fainting, and a difficulty of breathing are the results.

After we have respired the air, does it become greatly changed ?

It does ; carbon being one of the elements, unites with the oxygen, and thus forms carbonic acid.

Fig. 7.



How can you show that we breath out carbonic acid ?

Fill a tumbler with pure, clear lime water, and take a small glass tube, or straw, and blow through it : the whitening of the water will show the amount of carbon in the breath.

If we attempt to breathe nitrogen, hydrogen, or any other gas not containing oxygen, what would be the result?

Speedy death.

What changes the dark red, or venous blood, in the lungs, to arterial?

Oxygen changes the dark red or venous blood, to arterial, and makes it fit for the circulation of the system.

Is pure oxygen gas destructive to animal life?

It is; if a mouse is confined in a large tight jar full of air, it seems for some time to experience no inconvenience; but as the consumption of oxygen, and the exhalation of the carbonic acid proceed, the poor animal struggles for air, and in a few hours dies.

Is oxygen a supporter of combustion?

It is a powerful supporter; any body which will burn in common air, burns with greatly increased splendour in oxygen gas.

How can you prove it?

By lighting a taper, and placing it in a vessel of oxygen gas, it will kindle and burn for some time with great brilliancy.

Can you give another example?

Iron wire, or a steel watch spring formed into a coil, and heated at one end to redness undergoes rapid combustion in it.

Will lighted charcoal burn in oxygen?

Lighted charcoal emits beautiful scintillations.

What are some of the uses of oxygen?

It has long been used with good results in certain diseases, such as paralysis of the thorax, and general debility.

## LECTURE II.

### OXIDES AND ACIDS.

What are oxides, and what are acids?

When bodies unite with oxygen, two sets of compounds are produced, differing in many respects from each other, the one is called oxides or salifiable principles; the other acids or salifying principles.

How does an oxide differ from an acid?

The oxides differ from the acids in the want

of the sour taste which generally belongs to acids, and in their not changing vegetable blue colors to red.

Will oxygen combine with all substances?

Oxygen unites with most of the elementary substances; thus it may also combine with a body in several proportions and form both oxides and acids.

When there are several oxides of the same base, how are they designated?

The Greek numerals are prefixed to express the different proportions of oxygen, as protoxide, dent-oxide, trit-oxide, and per-oxide, the latter always expressing the highest degree of oxidizement in oxides.

When oxygen unites with hydrogen, what does it form?

Water.

When oxygen unites with nitrogen, what does it form?

Air.

When a small proportion of oxygen is mixed with another element, what name is given to the compound?

An oxide of oxygen.

What is rust?

The oxidation of iron in moist air.

Do any other metals combine rapidly with oxygen?

Yes; copper, lead, mercury, and even sil-

ver to some extent.

What is nitrous oxide ?

It is the smallest quantity of oxygen that will combine with nitrogen.

By what other name is it frequently called ?

Laughing gas.

Who first investigated the effect which it produces upon the human system ?

Sir Humphrey Davy, in the year 1799.

What effect did he find that it produced upon the system ?

It may be breathed without injury, but the effect varies much according to the temperament of the person who inhales it. | It produces a remarkable excitement in the system amounting to intoxication, and if carried too far, insensibility. | In some persons it produces great laughter, a rapid flow of vivid ideas, and an unusual disposition to muscular exertion. These feelings subside in a few minutes, and in general are not followed by anything more than a slight sensation of languor, although the results produced by it are sometimes injurious. In order to produce these effects without injury it should be quite pure and free from chlorine and inhaled through a wide tube, from a gas-holder or bag.

When a large quantity of oxygen combines with another element, what is the compound called ?

The name given to the compound is acid.

What is nitric acid?

Nitric acid is the greatest quantity of oxygen that will unite with nitrogen.

When, and by whom was nitric acid discovered?

Nitric acid was discovered about the year 1225, by Raymond Lully but Cavendish first made known its constitution in 1785

What are some of the properties of nitric acid?

Nitric acid is an odorous and poisonous liquid; it acts powerfully on substances which are disposed to unite with oxygen.

Is nitric acid of any use in the arts?

Nitric acid is a powerful solvent of the metals, it is used extensively in the arts for etching on copper, as a solvent of tin, to form a mordant for some of the finest dyes; and in medicine, as a tonic.

What is the nitric acid of commerce frequently called?

There are two kinds of nitric acid of commerce; the one, half of water, and is called double aqua fortis; another kind, three-fourths water, is called simple aqua fortis, which is half the strength of the double.

## LECTURE III.

### HYDROGEN.

What is hydrogen ?

Hydrogen is an inflammable gas.

Where is it found ?

Hydrogen is found in the ocean, and is widely disseminated through all animal and vegetable substances ; it forms two-thirds of water, is evolved from volcanoes, and is known to exist in coal ?

By whom was it proved to be a distinct gas ?

By Cavendish, an English chemist, in 1766, and was called by him inflammable air, from its combustibility.

From what is the word hydrogen derived ?

Two Greek words, which signify, a generator of water

What are some of its properties ?

Hydrogen is a colorless, inflammable gas, having neither odor nor taste when perfectly pure.

How can you obtain hydrogen gas ?

Hydrogen gas can be obtained in the following way : put a quarter of an ounce of zinc or

wrought iron filings into a flask, and pour over them two and a half ounces of water. No action takes place, but if half an ounce of sulphuric acid be gradually added, and the flask kept in constant motion, ebullition and heating of the liquid immediately ensues.

Is there any danger from this experiment?

Sulphuric acid burns anything it touches, therefore it is well to pour the water first in the flask, then the sulphuric acid, and shake them gently together, or it will become so hot as to break the retort.

Is hydrogen a combustible body?

It is, but not a supporter of combustion.

Can you give an example?

A candle kindles a jar of it, but is itself extinguished by immersion in the gas, and is re-lighted if the wick again touches the flame. It burns with a bluish white flame and a very faint light.

Is hydrogen a supporter of animal life?

It cannot support respiration alone, for an animal plunged into it soon dies for want of oxygen.

What does hydrogen with oxygen form?

An explosive mixture.

Give an example.

An air pistol filled with hydrogen and atmospheric air; the oxygen unites with the hydrogen and forms water, and caloric will be



evolved, which causes air to expand and collect at the end of the pistol.

Is hydrogen much lighter than atmospheric air?

It is the lightest body in nature, and is 16 times lighter than atmospheric air.

Give an example.

If soap bubbles are filled with hydrogen they will ascend rapidly.

With what kind of gas are balloons generally filled?

Large balloons are usually made of oiled silk, and inflated with hydrogen gas

When a stream of hydrogen gas is burnt under a tube, what is the result?

Musical sounds are produced, which is owing to the succession of continued explosions produced by the union of the hydrogen and the oxygen of the air.

When is hydrogen inflamed?

When directed upon platinum sponge, little balls of it suspended over the wick of an alcohol lamp, will in like manner glow for several hours after the lamp is extinguished.

How is the sponge prepared?

By dissolving platinum in nitro-muriatic acid and then precipitating it with ammonia.

Of what is muriatic acid a compound?

Of equal parts of chlorine and hydrogen.

Give an example.

Fill a jar half with chlorine and half with hydrogen, and put them in a dark place, no union ensues ; but it takes place instantaneously when the jar is exposed to the direct rays of the sun. The union is accompanied by a violent detonation which often breaks the glass.

What is a blow-pipe?

A tube usually bent at the end, terminating with a finely pointed nozzle for blowing through the flame of a lamp or gas jet, and producing thereby, a small conical flame possessing very intense heat.

What is the hydrogen blow pipe?

A mixture of oxygen and hydrogen, when ignited, produces an intense heat, and constitutes the hydrogen blow pipe.

By whom was it invented?

Dr. Hare of Philadelphia.

Can you describe the Drummons light?

The Drummons light is the ignited flame of oxygen and hydrogen, projected against lime, which becomes intensely luminous. It is extensively employed in distant night signals, and it can be seen farther at sea, than any other light. It is also used as a substitute for the sun's light in optical experiments.

## LECTURE IV.

### HYDROGEN WATER.

What is the only product of the combustion of hydrogen gas?

Water; Cavendish demonstrated it by burning oxygen and hydrogen gases in a glass vessel; when a quantity of pure water was generated, exactly equal in weight to that of the gases which had disappeared.

What is water?

Water is a fluid composed of oxygen and hydrogen, in the proportions of eight parts of oxygen to one part of hydrogen.

What are its properties?

Water is a transparent, colorless liquid, which has neither smell nor taste. It is a powerful refractor of light, conducts heat very slowly and is an imperfect conductor of electricity. It boils under ordinary circumstances at  $212^{\circ}$  but evaporates at all temperatures.

What is the greatest density of water?

The greatest density is found to be at  $39^{\circ} 5$ ; or, more exactly,  $39^{\circ} \cdot 83$ . It is the standard of comparison for all densities of solids and liquids, because it is more readily obtained than any other liquid.

What is said of the crystalization of water ?

In cold weather water freezes and forms beautiful crystals, and we frequently see snow beautifully grouped in compound crystals, resulting from the union of form, derived from the hexagonal prism.

Is pure water ever found on the surface of the earth ?

It is not, for the purest natural waters, evaporated to dryness, leave always a visible residue, which contains small quantities of earthly or saline matter which have been dissolved from the rocks and soils.

What is the purest water that can be found as a natural product ?

The purest water that can be found as a natural product is procured by melting freshly fallen snow, or by receiving rain in clean vessels, at a distance from houses ; but this water is not absolutely pure, for if placed under the exhausted receiver of an air pump, or boiled briskly for a few minutes, bubbles of gas escape from it. The air obtained in this manner from snow water is much richer in oxygen gas, than atmospheric air.

How is pure water obtained ?

It can only be obtained by distillation, and then it is rendered absolutely pure, and is employed for the purposes of analysis and pharmacy.

Does water contain any carbonic acid gas ?

All good water contains a considerable quantity of carbonic acid gas, otherwise it would be flat and unpalatable.

What are the solvent powers of water?

Nearly all saline bodies are to a greater or less extent, dissolved by water, and heat generally aids this result, pure water generally dissolves much quicker than common water. Hot water dissolves many bodies which are insoluble in cold.

Does water enter into combination with various bodies?

It does, sometimes it is contained in a variable ratio, as in solution, and in others it forms a mere accidental ingredient, as in common salt, or sulphate of potassium. In many cases it unites in a fixed definite proportion, as is the case in its combination with several of the acids, and metallic oxides, and of all the salts that contain water of crystallization.

What are these compounds called?

Hydrates.

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## LECTURE V.

### NITROGEN.

What is nitrogen ?

Nitrogen is an invisible gas, which abounds in animal and vegetable substances.

When and by whom was nitrogen first discovered ?

Nitrogen was first discovered by Dr. Rutherford, of Edingburgh, in the year 1772.

Was it discovered by any other persons ?

Yes. Lavoisier and Scheele discovered it several years after.

What name was it called by Lavoisier ?

Azotè, because it deprived animals of life.

From what is its present name derived ?

It is contained in saltpetre or nitre, whence its name nitrogen ?

Where is it found ?

Nitrogen constitutes four-fifths of the atmosphere, and enters into the composition of animals. It is found extensively in large caverns of Kentucky, It is given off by the hot springs of Scotland, and Lebanon Springs in the State of New York.

How can nitrogen be obtained ?

By burning a piece of phosphorus in a jar of air inverted over water ; the phosphorus unites with the oxygen of the air and forms phosphoric acid, which is absorbed by the water, and thus the nitrogen is left perfectly pure.

What are some of the physical properties of nitrogen ?

Nitrogen is a colorless, tasteless and inodorous gas ; it does not support combustion or animal life. A taper placed in it is extinguished immediately. And an animal placed in nitrogen gas dies from want of oxygen, it however possesses some remarkable properties of preserving.

When united with oxygen what does it become ?

It becomes a supporter of animal life, when united with oxygen in the proportion of five to one, in every other proportion it is destitute of this quality.

What are some of the uses of nitrogen ?

It is without use in the arts or in medicine. But it must perform some important office in the animal economy, since the only difference between animal and vegetable substances consists in the presence or absence of this principle.

When united with hydrogen what does it form ?

Ammonia, salt which is found on the banks of the Nile.

What are some of the properties of ammonia?

Ammonia is a colorless gas, which has a strong pungent odor so well known as harts-horn, (because it was procured formerly from the horns of harts) and acts powerfully on the eyes and nose. It is quite irrespirable in its pure form, but when diluted with air, it may be taken into the lungs with safety. It is strongly alkaline, restores the blue of reddened litmus, turns green the blue of cabbage, and neutralizes the most powerful acids.

Is ammonia a supporter of combustion?

It does not support combustion, for when a lighted candle is immersed in it, the flame is somewhat enlarged and tinged with a pale yellow color at the moment of being extinguished. A mixture of ammonical and oxygen gases detonates by the electric spark, water being formed and nitrogen set free.

What other names have been applied to ammonia?

Ammonia has received the names of harts-horn, spirits of hartshorn.

Is ammonia extensively used?

It is used extensively by the chemist to neutralize acids. Colors changed by sulphuric or any other acid, may often be restored by ammonia.



Is ammonia ever used by physicians?

Ammonia is used in medicine as a tonic ; it is the substance employed for smelling bottles.

Has it ever been found injurious?

Orfila adds a caution against its two frequent use with persons who have fainted. If they breathe it too long, the vapor inflames the throat and lungs, and thus produces death.

## LECTURE VI.

### NITROGEN AND AIR.

What is the atmosphere?

The earth is everywhere surrounded by a mass of gaseous matter called the atmosphere, which is preserved at its surface by the force of gravity, and revolves together with it around the sun.

What are some of the properties of air?

It is colorless, transparent invisible, excites neither taste nor smell when pure, and is not sensible to the touch unless when in motion, is perfectly elastic and compressible, has a pressure at the level of the sea equal to a weight of about 15 lbs on every square inch of surface, and can support a column of water 34 feet high, and one of mercury 30 inches.

What is said of its specific gravity?

Its specific gravity is unity, being the standard with which the density of all gaseous substances is compared. It is 814 times lighter than water, and nearly 11065 times lighter mercury.

By whom was the pressure of the atmosphere first noticed?

Galileo, early in the 17th century, and it was afterwards demonstrated by his pupil Tor-

ricelli, to whom science is indebted for the invention of the barometer.

Is the atmosphere of equal density in all parts?

It is not. Those portions which are near the surface of the earth bears the weight of that which is above it. Being compressed, therefore, by the weight of that above it, it must exist in a condensed form near the surface of the earth, while in the upper regions of the atmosphere, where there is no pressure, it is highly rarefied.

What is the air we breathe?

It is an elastic fluid, which surrounds the earth, extending to an indefinite distance above its surface, but from calculations founded on the phenomena of refraction, it is supposed to be about 45 miles high. If it was throughout its whole extent as dense as at the surface of the earth, its height would be about five miles.

Is air visible to us?

We cannot perceive it immediately around us, because it is perfectly transparent, but when we look up into the firmament illuminated by the sun, the air appears of a beautiful azure. Distant mountains appear of a blue color, owing to our viewing them through the atmosphere.

What are the elements of atmospheric air?

It consists of two principal ingredients, called oxygen and nitrogen, or azoté; of the former of which there are 25 parts, and of the latter 72 in a hundred.

What is the best method to determine the relative quantity of oxygen in the atmosphere?

By detonating it with pure hydrogen, two measures of which will of course require precisely one measure of oxygen for its combustion.

How is the analysis of air accomplished?

By means of an instrument called a Eudiometer of which there are several varieties.

What is this Eudiometer?

It is a graduated tube, closed at one end and bent on itself. When used it is filled with dry mercury, by placing it horizontally in the mercury trough. A portion of the gaseous mixture to be detonated is then introduced, the thumb placed over the open end, and all the mixture adroitly transferred to the closed limb. The mercury is made to stand at the same level in both limbs by forcing out a portion with a glass rod, thrust in at the full side. These adjustments being made, the whole bulb of the mixture is read on the graduation, and while the thumb is firmly over the open end of the tube, an electrical spark is made to explode the gases. The air between and the mercury acts like a spring to break the force of the explosion; and afterwards on removing the

thumb, the weight of the atmosphere forces the mercury into the shorter leg, to supply the partial vacuum occasioned by the union of the gases. Proper allowances being made for temperature and pressure, the quantity of residual gases is read on the graduation, and calculation can then be made of the amount of oxygen present.

Can you give an example of eudiometry, or analyzing the atmosphere?

One of the simplest methods consists in removing the oxygen by the slow combustion of phosphorus. For this purpose a stick of phosphorus is sustained on a platinum wire, or in a confined portion of air, contained in a graduated tube, whose open end is beneath the water. A gradual absorption takes place, and in about twenty-four hours the water ceases to rise in the tube, by which we know that the phosphorus has removed all the oxygen. The water absorbs the resulting phosphoric acid, and we may read off, by the graduation on the tube the amount of oxygen removed.

Is the atmosphere ever pure?

It is never absolutely pure, for it always contains a certain variable quantity of carbonic acid and watery vapor, besides the odiferous matter of flowers and other volatile substances.

Does the atmosphere contain the greatest proportion of carbonic acid in summer or winter?

In summer, and from observations made during spring, summer, and autumn in the open fields and in calm weather, its proportion is inferred to be always greater at night than during the day, and to be more abundant in gloomy than bright weather.

To what do the chemical properties of the atmosphere owe their presence?

Oxygen gas; air from which this principle has been withdrawn is nearly inert; it can no longer support respiration, animal life, or combustion.

Why is there so much nitrogen in the air?

In order to dilute the oxygen, the uses of nitrogen are in a great measure unknown, but it has been supposed to act as a mere diluter to the oxygen, but it most probably serves some useful purpose in the economy of animals, the exact nature of which has not been discovered.

## LECTURE VII.

### CARBON.

What is carbon?

Carbon is a solid substance, generally of a dark color.

Where is carbon found?

It exists abundantly in the animal, vegetable, and mineral kingdoms; it is rarely found perfectly pure in nature.

Is carbon an important and useful substance?

It is one of the most interesting of the elementary bodies, and our interest in it is not diminished from the fact that the charcoal and mineral coal which we use as fuel, and the black lead of our pencils, are essentially the same thing with that rare and costly gem, the diamond.

Where is pure carbon found?

The only pure carbon is found in the diamond.

Of what is the diamond supposed the origin?

From its high refractive power it is supposed to be of vegetable origin. It is a non conductor of heat and electricity and is very un-

alterable by chemical means.

Where is the diamond found

In many parts of the East Indies, Brazil, and it is also found in Diluvium. A few have been found in the United States, chiefly in North Carolina.

Are diamonds of various colors?

Diamonds have been found of nearly every color, but the colorless diamonds are considered the most valuable. They are often slightly colored of a yellowish, rose, blue, or green and even black tint.

What is the hardest body in nature?

Diamond is the hardest of all bodies and can be scratched or cut only by its own dust, it has not the slightest resemblance to coal, yet it can be entirely burnt up in oxygen. Carbonic acid is the only product obtained from it.

What are some of the other kinds of carbon?

Plumbago, anthracite, bituminous coal, peat, lamp-black, ivory-black, charcoal, &c.

What is graphite or plumbago?

Graphite or plumbago is nearly pure carbon and is found in rocks, it is frequently called black lead, and is used for pencils, crayons, and for giving a black polish to iron articles, such as stoves, &c.

What are some of the properties of graphite?



It is found crystallized in flat six-sided prisms a form altogether incompatible with that of the diamond ; it is soft, flexible, easily cut, feels greasy, and marks paper.

What is anthracite ?

Anthracite is a species of coal which is used in many parts of the United States ; it is found in Pennsylvania, and in the south eastern part of Massachusetts ; it is one of the densest and purest varieties of mineral coal.

What is the difference between anthracite and bituminous coal ?

Anthracite has been exposed to heat, and the bitumen burned out while the other has not.

What is peat ?

Peat is a vegetable substance, and is generally dug from swamps ; but when dry it is often used for fuel when better cannot be obtained.

What is soot ?

Soot is coal in a state of minute division, which is deposited from carbonaceous gases, commonly from illuminating gas, and is well known as a most important black coloring substance from printing ink.

What is coke ?

Coke is a species of coal of a gray color, more or less porous, very hard, has a metallic lustre, and gives out an intense heat. It is an

excellent fuel, and especially adapted for the smelting of iron and the heating of locomotive boilers.

What is lamp black, and how is it obtained ?

Lamp black is a species of carbon, a superior quality of soot, and is obtained by the burning of turpentine, pitch, pine, &c.

What is ivory black ?

Ivory black is an animal charcoal, and is obtained by burning bones, excluded from the air.

What is charcoal, and how is it obtained ?

Charcoal is a species of carbon, and is made for the common purpose of fuel, by a sort of smothered combustion ; it is also prepared by wood being exposed to heat, in large iron cylinders.

Is it not used extensively in commerce ?

It is, for preparing food, to prevent the putrefaction of meat and vegetables, for refining sugar ; and by filtration, water is rendered pure.

What are some of the properties of charcoal ?

Charcoal is an excellent conductor of electricity, but a bad conductor of heat, it is also very combustible in oxygen gas.

Why is water purified by being filtered through charcoal ?

The charcoal absorbs the impurities of the water, and removes all disagreeable tastes and smells, whether they arise from animal or vegetable matter.

Why does coal make such excellent fuel ;

Because it contains a large amount of carbon and hydrogen gas, in a very compact and convenient form.

## LECTURE VIII.

### CARBONIC ACID.

Where is carbonic acid found?

Carbonic acid exists in nature, and is obtained by burning charcoal in the air, or in oxygen.

What are some of the properties of carbonic acid?

It is a colorless, inodorous, and elastic fluid.

What causes the effervescence which takes place on opening a bottle of beer?

The carbonic acid escapes, and this causes the effervescence which takes place on opening a bottle of beer. The "soda water" so much used as a beverage, is usually only water strongly impregnated with carbonic acid, the soda being generally omitted in its preparation the effervescence of this is due to the escape of the gas.

Is carbonic acid ever found in the atmosphere?

Carbonic acid is always present in the atmosphere, being given off by the respiration of all animals.

Can you give an example?

Carbonic acid and lime have a strong attrac-

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## LECTURE IX.

### CARBURETTED HYDROGEN.

What is carburetted hydrogen ?

Carbon combined with hydrogen.

By what names is it sometimes called ?

Inflammable gas, olefiant gas, and sub-carburetted hydrogen, but it is generally termed light carburetted hydrogen.

How is it formed ?

Carburetted hydrogen is formed abundantly in stagnant pools, during the spontaneous decomposition of dead vegetable matter.

How may it be collected ?

It may readily be procured by stirring the mud at the bottom of the pool, and the bubbles which rise are light carburetted hydrogen, the gas as it escapes may be collected in an inverted glass vessel.

What are its properties ?

Light carburetted hydrogen is tasteless and nearly indorous, and it does not change the color of litmus paper. It extinguishes all burning bodies, and is unable to support the respiration of animals. It is highly inflammable; and when a jet of it is set on fire, it burns with a yellow flame, and with a much stronger light than is occasioned by hydrogen gas; when mingled with a proper quantity of

oxygen gas, it forms a mixture which may be kindled by flame or the electric spark, and which explodes with great violence.

What kind of gas is now generally employed for the purposes of illumination?

Mixed gas, composed mostly, however, of olefiant is chiefly used for purposes of illumination.

Why was it called olefiant gas?

From its property of forming an oil-like liquid with chlorine.

When was coal gas first introduced for purposes of illumination?

In the year 1792 by Mr. Murdock. Coal furnishes carburetted hydrogen, by being distilled at red heat in large iron retorts. The coal at Richmond, Va., yields a large quantity of gas.

Has oil gas any advantages over coal gas?

Oil gas contains a much greater proportion of carburetted hydrogen than coal gas.

What has in a great measure prevented the use of gas lights?

The expense of gas-works has prevented their use, but within a few years past, arrangements have been made by which whole cities are lighted with gas.

What is the gasometer?

The gasometer is a large inverted vessel made of iron. The gas is introduced by pipes



ascending from the bottom of the reservoir, and rising a little above the surface of the water.

What was the fire damp of coal mines proved to be ?

Identical in composition with light carburetted hydrogen. It often issues in large quantities from between the beds of coal, and is composed of several gaseous compounds of carbon and hydrogen. This gas when mixed with atmospheric air, is liable to take fire from the flame of a lamp or candle ; it is this which causes such frequent explosions in mines. These accidents, which were formerly so frequent and fatal, are now comparatively rare, owing to the employment of the safety lamp.

To whom are we indebted for the safety lamp ?

To Sir Humphry Davy, a very ingenious chemist, who was born in Cornwall, 1778, and died in 1829.

How is it constructed ?

It consists simply of a common lamp, the flame of which is wholly enclosed in a cylinder of fine wire gauze, which allows the hydrogen to pass through.

What did Sir Humphry Davy ascertain in relation to wire gauze ?

That it would in all cases arrest the progress of flame, and that a mixture of explosive gases could not be fired through it. The wire

gauze, being a powerful conductor and radiator of heat, cools a flame which is in contact with it, so as to deprive it of the power of producing an explosion on every side.

What is wire gauze ?

It is a series of short square tubes.

What will be the result, if this lamp be immersed in an explosive mixture ?

The gas will be inflamed, and burn on the inside of the gauze cylinder, but not on the outside.

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## LECTURE X.

### COMBUSTION.

What is combustion ?

Combustion is the disengagement of light and heat, which accompanies some cases of chemical union.

What three elements are necessary to produce combustion ?

Hydrogen gas, carbon and oxygen.

How is the term restricted ?

To the union of bodies with oxygen, with development of light and heat, thus carbon, sulphur, phosphorus are familiar examples of elementary combustibles, while oil, tar, coal, wood, are compound ones.

Give an example showing the successive combustibility of bodies ?

Introduce a lighted taper into a long bottle, and let it burn till it is extinguished. Carefully stop the bottle and introduce another lighted taper, and it will be extinguished before it reaches the bottom of the neck. Then introduce lighted sulphur, this will burn for some time, and after its extinction, phosphorus will be as luminous as in air, and if it be heated, will burn with a pale yellow flame.

In cases of combustion is the action reciprocal?

It is. Hydrogen burns in common air; but if a stream of oxygen is thrown into a jar of hydrogen, through a small aperture at the top, when the latter is burning, the flame is carried into the body of the jar, and the oxygen will continue to burn in the hydrogen, as it issues from the jet, in this case the oxygen may be said to be combustible, and the hydrogen the supporter.

Has heat produced by combustion received any satisfactory explanation?

It has not. Why the union of carbon and oxygen with hydrogen, to form a gas should evolve such intense heat as to fuse the most refractory bodies, is as yet unexplained.

At what temperature do bodies become visible in the dark?

Bodies become visible in the dark at about 1000° of heat. This fact has been lately confirmed by the researchs of Draper, on shining by heat a piece of platinum in the dark, when heated by a current of voltaic electricity.

What are the elements of fuel?

A compound of hydrogen and carbon?

What causes the combustion of fuel?

The hydrogen gas of the fuel, when ignited by a match, unites with the oxygen of the air,

and makes a yellow flame which heats the carbon of the fuel.

What is fire ?

Heat and light which is produced by the combustion of inflammable substances.

Why is a fire after it is properly ignited and been left burning for a while, red hot

Because the whole surface of the fuel is thoroughly heated, and every part of it is undergoing a rapid union with the oxygen of the air.

What is smoke ?

Smoke consists of all the dust and visible particles which are separated from the fuel without being burned, and are light or minute enough to be carried aloft by the rising current of heated air.

Is smoke heavier than air ?

All that is visible of smoke is really heavier than air, and soon falls again, as powdered chalk falls in water.

Why is there more smoke when fresh fuel is added to a fire ?

Because carbon requires a great degree of heat in order to unite with oxygen, therefore when fresh fuel is laid in, more carbon is separated than can be reduced to combustion, and the surplus flies off in smoke.

Why does fire burn more rapidly in windy weather ?

Because the air affords plentiful nourishment to the fire.

Why does water sprinkled on coal or cinders make it burn more rapidly than it would without?

Because the hydrogen of the water burns with a flame, and the oxygen of it increases the intensity of that flame.

Is combustion ever produced spontaneously?

It is. Goods piled up often catch fire themselves, especially if they are placed in a damp place.

Can you explain this.

Damp produces decay, fermentation commences and carbonic acid gas is formed, which is attended with combustion.

Why do hay stacks sometimes spontaneously take fire?

Because the hay was put up damp, or penetrated by the rain, a slow combustion ensues, till at length the stack burst into a flame.

## LECTURE XI.

### FLAME.

What is flame ?

The rapid combustion of volatized matter.

Are all flames equally luminous?

They are not, those substances, which, during combustion, produce chiefly gaseous or volatile matter, emit from their flame a very feeble light, as is seen in burning hydrogen or sulphur, those on the other hand which produce particles of solid matter, during their combustion yeild a white flame and a greater illumination.

What is noticed of the structure of flame?

That it is formed of several distinct parts, so to speak, wrapped conically about each other.

What has Davy asserted in regard to the flame of combustible bodies?

That the flame must be considered as the combustion of an explosive mixture of inflammable gas or vapor and air, and that this combustion takes place in the interior as well as the surface of contact.

Can you prove by example that no combus-

tion goes on in the interior of a flame?

Place a piece of coin or metal upon an earthen plate; place a small piece of phosphorus upon the coin, and surround the latter with alcohol. The alcohol may be fired without setting fire to the phosphorus, which remains unaffected in the interior of the flame, but as soon as the external air comes in contact with it combustion instantaneously takes place.

Does flame possess a very high temperature?

It does, it was estimated by Sir H. Davy at  $7000^{\circ}$  F. but there can be no doubt that the temperature varies with the combustible and perhaps never reaches the point mentioned by him.

Of how many portions do the flame of a candle consist?

Three, although these may be modified by various circumstances. The innermost cone is made hollow, the outside one yellow, and the intermediate one a dingy purple blue.

What is necessary in order to support flame?

That the supply of combustible matter should be in contact and uniform, and for this purpose the combustible must be in a liquid, or gaseous state, when it approaches the flame, so that it may flow in an uninterrupted current.

Why is the flame of a candle carried up-



ward?

As the tallow melts by the radiated heat of the flame, it is carried upward by the capillary attraction of the wick, and is converted into vapor, as soon as it reaches the surface.

What prevents the wick from being consumed?

It is surrounded by inflammable vapor, so that the oxygen of the air has no access to it.

What is the reason why the wick of a tallow candle requires snuffing?

Because tallow being more fusible than wax requires to be burnt with a larger wick, and when suffered to become long it divides the blaze, and intercepts a part of the light, it also cools the flame by its radiation, obstructs the combustion, and thus causes the escape of smoke, and the deposition of charcoal.

Why do not wax or spermaceti require snuffing?

Because the wick is made sufficiently slender bends out the flame, and burns off, so as not to require snuffing.

What is the principle of the Argand burner?

The intention of the Argand burner is to furnish a more rapid supply of air to the flame and to afford this air to the centre, as well as to the outside of the flame.

How is the Argand lamp constructed ?

By forming a hollow cylindrical cavity, which receives oil from the main body of the lamp, and at the same time transmits air through its axis or central hollow. In this cavity is placed a circular winch, attached at the bottom to a movable ring, which is capable of being elevated or depressed by means of a rack and pinion, or more commonly by a screw ; so that the height of the wick may be varied to regulate the size of the flame. On the outside is placed a glass chimney, which is capable of transmitting a current of air, on the same principle as a common smoke flue. When this lamp is lighted the combustion is vivid, and the light intense, owing to the free and rapid supply of air.

## LECTURE XII.

### SULPHUR.

What is sulphur ?

Sulphur is a brittle solid, of a greenish yellow color.

What is the history of sulphur ?

Sulphur has been known from the remotest antiquity, and is found abundantly in nature. It is also found in craters of volcanoes, in the island of Sicily, the vicinity of Naples, in Cuba and many other places.

How many forms has sulphur ?

Sulphur has two forms : the flowers of sulphur, and the roll commonly called brimstone. but the two varieties are readily resolved into each other by the application of heat.

Give an example.

Heat a brick or small iron cup, to nearly a red heat, place upon it roll brimstone, and invert over it a bell glass receiver ; the sulphur will sublime ; that is, pass into a fine powder, like vapor, and collect on the sides of the vessel. In this way the flowers of sulphur are prepared.

Which is the most pure ?

The flowers of sulphur.

What are some of the properties of sulphur ?

It is a simple inflammable body of a straw yellow, brittle, cold at common temperature, is tasteless, without odor until rubbed. It is insoluble in water and nearly so in alcohol and ether.

Where is sulphur found pure ?

In craters of volcanoes, in regular crystals and in combination with various metals, as, for instance, antimony, iron and copper forming sulphates.

Has sulphur any affinity for the metals ?

Sulphur in its moist state, and when dissolved in water has a very great affinity for metals, and converts metals, metallic oxides, and salts into sulphur metals.

How is sulphur separated from the metals ?

By heat, it melts at  $220^{\circ}$ , and takes fire at  $500^{\circ}$ , Fahrenheit.

Has pure sulphur any odor ?

It has not, except that which is supposed to arise from its impurities.

Is sulphur a non-conductor of electricity ?

It is, but when excited it will attract light substances.

Is sulphur an acidifiable substance ?

It is when united with nitrate of potassa and

inflamed under a bell glass.

Will the oxygen of the nitric acid unite with sulphur?

The oxygen of the nitric acid unites with the sulphur and forms sulphuric acid.

What are some of the uses of sulphur?

It is extensively employed in the manufacture of sulphuric acid; in that of gunpowder, matches, and it is used to form moulds for plaster casts, for taking impressions of seals, &c.

Is it ever employed in medicine?

In medicine it is employed both as an external and internal remedy, especially in diseases of the skin.

How can the impurities of sulphur be tested?

By heating sulphur upon a piece of platinum leaf; if impure the sulphur will evaporate and leave the earthy substance.

Is pure sulphur soluble?

Pure sulphur is perfectly soluble in boiling oil of turpentine, which is one of the tests of its purity.

Is arsenic ever found in sulphur?

It is, frequently.

Can sulphur be crystallized?

It may be by fusing several pounds of it in a large crucible and allowing it to cool slowly.

Is sulphur ever met with in vegetable sub-

stances?

It is, particularly in the leguminous plants, peas, beans, lentils. &c., and in some acid plants such as mustard, horseradish, &c.

Is it ever found in springs of water?

Sulphur, combined with hydrogen, is found in some mineral waters, and it may be recognized by the smell and taste; these springs are resorted to by invalids, and are called sulphur springs.

What are some of the properties of sulphurous acid gas?

Sulphurous acid gas is fatal to animals confined in it, it is not combustible, but extinguishes burning bodies. It possesses the property of bleaching, and is used for that purpose; thus straw bonnets are bleached by the fumes of sulphur.

What is the process of bleaching straw?

Take a plate of sulphur, and place it in the bottom of a barrel which contains the article, then set the sulphur on fire, and this produces sulphuric acid, then by keeping the barrel covered, the acid will bleach the straw.

What effect has sulphurous acid upon the color of vegetables?

If sulphuric acid be applied to vegetable colors it will turn blue to red, and will destroy red entirely.

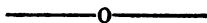
Which is the strongest, sulphurous or sul-

phuric acid?

Sulphuric acid.

Does sulphuric acid ever occur free in nature?

It does frequently.



## LECTURE XIII.

### PHOSPHORUS.

What is phosphorus?

Phosphorus is a simple inflammable body, usually obtained from animal bones, at 148° Fahrenheit, it takes fire, and burns with great brilliancy. Great care is required in experimenting with it, as it continues burning with great violence.

When, and by whom was phosphorus discovered?

It was discovered in 1669 by Brand, an alchemist of Hamburg, but the secret of obtaining it remained a considerable length of time.

Where is phosphorus found?

It is found nowhere free in nature, but exists largely in the animal kingdom combined with lime, forming bones. It is found widely diffused in the mineral kingdom and is also introduced into the animal system by the plants used as food.

What are some of the properties of phosphorus?

Phosphorus is an almost colorless, transparent solid, which, like sulphur, melts, boils, evaporates, and burns, but much easier and more rapidly; and at ordinary temperature cuts with the consistency and lustre of wax. Exposed to light, it soon becomes yellow, and finally red. It is insoluble in water, but it is partially soluble in ether, alcohol, and various oils.

How is it kept?

Phosphorus should always be kept under water, and in winter alcohol may be added to prevent its freezing. If exposed to the air, it wastes slowly, and it has such a strong affinity for oxygen, that it takes fire at common temperature, and when placed in pure oxygen gas it burns with great splendor, forming one of the most brilliant experiments in chemistry.

From what did phosphorus receive its name?

The property it possesses of shining in the dark and even in daylight it appears to be surrounded by a light cloud.

Can there be any experiments performed by



means of phosphorus?

There can be a great many amusing experiments performed, for instance, words or figures drawn on the wall of a dark and warm room, with a stick of phosphorus, will leave traces which at night looks like fire.

Is phosphorus poisonous?

Phosphorus is an exceedingly violent poison, but it is used sometimes as a medicine.

Is phosphorus much used in the arts?

It is not, but the lucifer matches are, however, made of it, which ignite by slight friction.

Why will matches ignite by merely drawing them across any rough surface.

Because they are made of phosphorus which has an affinity to oxygen at the lowest temperature,

What is the process for obtaining phosphorus?

The most common process of obtaining phosphorus is by igniting bones in an open fire until they become white, so as to destroy all the animal matter which they contain, and oxidize the carbon which proceeds from its decomposition.

511

## LECTURE XIV.

### CHLORINE.

By whom was chlorine discovered ?

It was first discovered by Scheele, in 1774, and it derives its name from the Greek *chloros*, green, in allusion to its color.

What are some of its properties ?

Chlorine is of a yellowish green color, has an astringent taste and disagreeable odor; it emits light and heat when strongly compressed, and is one of the most suffocating of the gases, exciting spasm and great irritation of the glottis, even when considerably diluted with water.

Is it a simple or compound substance ?

Some suppose it to be a simple, others a compound substance; both theories are, however, well supported.

Is chlorine a supporter of combustion ?

It is. If a lighted taper be plunged into a vessel of chlorine gas, it burns brilliantly.

Are any of the metals inflamed when introduced into it ?

Several of the metals, such as tin, copper, arsenic, antimony and zinc are suddenly inflamed when introduced into it.

What is one of the most important properties of chlorine ?

The power it possesses of bleaching.

Give an example in illustration of this principle?

If a strip of calico be introduced into a solution of the chlorine, colors will soon be completely discharged, linen, cotton, paper and other materials may now be rendered perfectly white by it in a few hours. It does not bleach woollens, nor printers ink, probably because of its indifference to carbon, which forms the basis of printers ink.

Is chlorine a disinfecting agent?

Chlorine is a powerful disinfecting agent, and is used for purifying all infected atmospheres, and for arresting the decay of organized substances.

On what does this power depend?

On its great affinity for hydrogen. It decomposes every species of animal and vegetable effluvia, hence its utility in contagious diseases.

Do you remember any other uses to which chlorine has been applied?

It has been found very useful in dissecting rooms, and the chlorate of lime is frequently used for cleansing the apartments of the sick, it also purifies the air when charged with miasma.

Should the apartment in which chlorine of lime has been used for cleansing, be ventilated before it is again occupied?

It should, or persons who have weak lungs might receive serious injury from it.

Where is chlorine chiefly found?

In the ocean, and in the rock salt which is dug out of the earth.

Is chlorine destructive to animal life?

It is. A few bubbles of gas in the atmosphere of a room will bring on coughing. Pelletier is said to have fallen a victim to its effects. The antidote is ammonia.

What are some of the tests of chlorine?

Chlorine is detected by its bleaching properties, color and odor.

If a stream of chlorine is introduced into a glass receiver, containing bicarburetted hydrogen, what is the product, and by what name is it called?

An oily compound is produced, which is the oil of the Dutch chemists, and from this circumstance, the bicarburetted hydrogen was called by them olefiant gas.

## LECTURE XV.

### CHLOROFORM.

By what name has chloroform been known?  
Dutch oil, or oil of the Dutch chemists.

From what is its name derived?

It derives its name from being discovered by an association of Dutch chemists at Harlæm, in 1796; who also discovered, at the same time, bicarburetted hydrogen.

Are the terms chloric ether, bichloric ether, perchloride of formyle, Dutch oil, and oil of Dutch chemists, synonyms of chloroform?

They are.

Has there ever been a substance discovered which resembles chloroform?

There has. By the action of bleaching powders on alcohol, aided by heat, a substance was discovered, analogous in every respect to chloroform. This effect was discovered almost simultaneously by Mr. Samuel Guthries, of Sackets Harbor, N. Y., and M. M. E. Soubeiran, of France.

What is the process, as taken from Silliman's Journal of March 1848, page 241?

"About six pounds of dry bleaching powder (chloride of lime) was introduced into a

copper still containing about four gallons of water, and of a capacity equal to ten or twelve gallons half a gallon of common alcohol (80 per cent) added; the materials thoroughly agitated and a cautious distillation commenced. A powerful condensing apparatus is attached, and very soon the dense globules are seen coming over dropping into the water. The larger portion of the fluid is given off before the heat is intense enough to distil over much alcohol. It would be advisable to charge the receiving vessel as soon as the process is supposed to be about half done, as the first proportions are the richest, and if allowed to mingle with the second portion, the product of the distillation is much smaller, because a very small portion of alcohol will dissolve a very large quantity of chloroform. The product of distillation is washed with cold water, which is continued until no further diminution of chloroform is observed; it is then fit for medicinal purposes. The 'caput mortuum' in the still is not capable of producing any appreciable effect on the addition of more alcohol."

What does the solution of chloride of lime deposit?

An abundant crop of delicate acicular crystals, whose composition has not yet been ascertained.

What amount does the above proportions

About six or eight ounces of pure chloroform.

Chloroform thus prepared, possesses what properties?

Chloroform thus prepared, has the following properties: Specific gravity 148; boils at  $140^{\circ}$  Fahrenheit, and is not inflammable; but according to Soubeiran, its vapor when directed from a jet in alcohol blaze, burns with much smoke. It is an oily volatile, perfectly pellucid, sweet aromatic taste, and of a fragrant color.

Does it burn when mingled with alcohol?

Chloroform burns when mingled with an equal volume of alcohol.

Does it dissolve iodine?

It does; and potassium decomposes it at low temperatures, forming chloride of potassium, (common salt), disengaging hydrogen and carbon. It is decomposed by oxide of barium and oxide of calcium, metallic chlorides being produced, and carbon and hydrogen given off.

Does sulphuric acid act on it at common temperatures?

It does not.

Does hydrochloric acid change it at high temperatures?

It does not. But when nitric acid is heated with it, a small quantity of nitrous acid is dis-

engaged. Solution of potash produces a slow decomposition.

By what name has the compound chloroform been called ?

Chloric ether.

Is that term inappropriate ?

It is; as this curious substance bears no analogy to the ethers. Chloric ether is more properly applied to the perchloric described by Booth and Boyè, which possesses a very explosive power.

Does the class of ethers possess properties common to chloroform ?

They do not. For instance, a *watery solution of potassa* promptly decomposes the ethers, taking up two equivalents of oxygen and forming alcohol and chlorine ; but no action of so extended a decomposition is manifest in the case of chloroform.

Are iodoform and bromoform analogous to chloroform ?

They are compounds which are strikingly analogous to chloroform. All are acted on and decomposed by an *alcoholic* solution of potassa, affording a compound of the salt radical with potassium, and also formate of potassa.

Does chlorform give any perceptible trace of that element, when treated with nitrate of silver ?

It does not, although it contains 83 percent



of chloroform, a result which will not be considered anomalous if we apply to it the law which governs all similar substitutions, with regard to products in which the *electro-negative elements exists in an electro-positive* allotropic condition.

What is this substance named by Graham?

By Graham, chloroform is named bichlorinated methyl, which term undoubtedly expresses in full its chemical constitution; for the fourth equivalent of hydrogen which it contains may be replaced by exposing chloroform to the action of chlorine in the sun's rays; the result will be perchlorinated methyl. M. I. Isidore Pierre, in an article ("Sur un nouveau dèrivè choloric de la liqueur des Hollandais"), gives a new compound derivative of Dutch oil. His views of the Dutch liquid, however, are different from Mr. Sillimans

What is the action of chloroform on the animal economy?

Chloroform, in its action on the animal economy, resembles sulphuric ether. Its vapor being inhaled, produces a complete paralysis of the nerves of sensation; taken in large quantities, death is the consequences, preceded by coma and general prostration of all the nervous energy.

What renders the use of chloroform important in medicine?

It is the power of inducing a complete ab-

sence of sensation that has given it its important place for medicinal uses ; it is also very analogous in its effects to nitrous oxide, causing death when inhaled in too large quantities.

Has chloroform been used extensively for inducing sensibility to pain ?

It has, and though but very few cases have occurred in which it was injurious, still much care should be exercised in administering it.

Have any cases of death occurred from its use ?

Yes, several, hence it is more restricted in its application. Of its *modus operandi* on the system, we can say nothing, or at most but very little, and that little of but limited use as yet on which to hazard an opinion.

## LECTURE XVI.

### IODINE AND BROMINE.

When, and by whom was iodine discovered?

Iodine is a solid body, and was discovered in 1812 by M. Courtois, a manufacturer of salt-petre at Paris,

Where is it found?

Iodine is frequently found in nature among fuci, which grow on the sea shore, in sponges and in various salt springs. It is also found in the mineral kingdom, in combination with silver.

Of what color is iodine?

Iodine is of a bluish black color, and has a metallic lustre; it is very volatile, rising in a rich colored vapor at a temperature of between  $80^{\circ}$  and  $100^{\circ}$  F.

From what does it derive its name?

A Greek word, meaning violet colored.

What are some of the properties of iodine?

Iodine is a non-conductor of electricity, has an acrid taste, and is sparingly soluble in water.

Can phosphorus be fired by iodine?

It can, by dropping upon it a few scales of iodine.

What is a delicate test for the presence of iodine ?

Starch is a delicate test, being changed by it to a beautiful blue color. By this test a millionth part of iodine can be detected.

Is iodine poisonous ?

Iodine is a very energetic poison.

Has iodine ever been used as a medicine ?

It has, with much success in various diseases. In the disease known by the name of goitre, it is almost an infallible cure.

Does iodine change vegetable colors ?

It does, but less powerfully than chlorine.

Give an experiment.

Boil one grain of starch, one drachm of water, add to this a few drops of tincture of iodine ; the iodine will combine with the starch, and form a deep blue color, which disappears on boiling, but appears again on cooling ; if one drop of the starch paste is mixed with one quart of water, the iodine tincture will impart to it a violet tinge.

By whom was bromine discovered ?

Bromine was discovered by M. Balard, of Montpellier, in the year 1826 ; it was described by him under the name of muride, because obtained from the sea. It has since been chan-

ged to bromine, from the Greek, bromus, in allusion to its strong odor.

Where is it found ?

It is widely diffused in nature, and in combination with various basis in the sea waters, and in nearly all salt springs. It is also found in a few minerals. Bromine is exceedingly volatile, and when exposed to the air, passes off as a gas, which is extremely poisonous.

Is bromine noxious ?

Bromine is very noxious when inhaled, and very poisonous when swallowed.

Does bromine possess bleaching properties ?

Bromine possesses bleaching properties; acts powerfully on animal and vegetable bodies, and corrodes the skin.

Is bromine a supporter of combustion ?

It is, antimony and tin take fire, and potassium when brought in contact with bromine.

What is a test of bromine ?

Bromine is easily detected by means of chlorine.

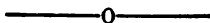
Is bromine ever used as a medicine ?

It is used for dispelling tumours, and in the treatment of scrofula.

Is bromine used in the arts ?

It is used by Daguerreans. They take polished silver plates and hold them over the flames of iodine and bromine ; this film of io-

dine and bromine of silver is decomposed almost instantaneously in the light, slowly in the shade, and not at all in the dark. It has been largely prepared at Freeport, Pennsylvania, on the Ohio, for use in pharmacy.



## LECTURE XVII.

### FLUORINE.

In what state does fluorine exist ?

Fluorine exists in a state of combination with lime. It appears to belong to a class of negative electives, and like oxygen and chlorine, to have a powerful affinity for hydrogen and metallic substances.

What are some of the properties of fluorine ?

It is a yellowish brown gas, having the smell and bleaching properties of chlorine. It does not act on glass, but unites immediately with gold.

Of what is fluorine one of the constituents?

Fluorine is one of the constituents of fluor spar, from which mineral, the compounds of fluorine are obtained,

How is hydrofluoric acid obtained?

By heating a mixture of sulphuric acid, and powdered fluor spar.

When and by whom was this substance first discovered?

This substance was first discovered by Berzelius, in 1818, who gave it its present name, from the moon.

Where is it found?

Selenium is found among the volcanic products of the Lipari Islands, combined with lead, cobalt, silver, mercury, and copper.

What are some of the properties of selenium?

It is a brittle opaque solid, without taste or odor, resembling sulphur, in most of its properties. At a common temperature it is a brittle solid, opaque, having a metallic lustre, like lead, but in powder it is of a deep red color.

How is chlorine of selenium obtained?

By placing selenium in chlorine gas,

How is bromine of selenium obtained?

By dropping selenium into bromine.

How is selenic acid formed ?

Selenic acid is formed when selenium is burned by nitrate of potash.

## BORON.

By whom was boron first obtained ?

Boron was first obtained by Davy, in 1807 ; its properties were first investigated by Gay, Lussack, and Thénard, and it is known chiefly by its compounds, borax, and boracic acid.

Is borax ever found entirely pure in nature ?

It is not, it is found in the East Indies and in the craters of volcanoes.

What are some of its properties ?

It is a dark olive green colored substance, which has neither taste nor smell ; it is a non-conductor of electricity, insoluble in water, alcohol, ether, and oil.

By whom is boron principally used ?

Blacksmiths, in welding iron,

Boron, united with oxygen, forms what ?

Boron when heated to  $600^{\circ}$  in air burns brilliantly and forms boric acid.

Where is this acid sometimes found ?

In the hot springs of Lipari, it occurs under the form of borax, a native compound of bora-



cic acid and soda.

What are some of the properties of boracic acid.

It is a white pearly substance in thin scales, which have a feeling like spermaceti, are feebly acid to the taste, and soluble in twelve parts of boiling and in fifty parts of cold water. Alcohol dissolves boraic acid, and the solution when set on fire burns with a peculiar green.

How is it prepared for chemical purposes?

By adding sulphuric acid to a solution of putrefied borax in about four times its weight of boiling water.

In what gas does it burn?

Boron burns with great brilliancy in chlorine gas.

Is boraic acid ever used in commerce?

This acid has become very common, and is sometimes used with soda in the manufacture of borax.

## LECTURE XVIII.

### SILICON

What is said of silicon ?

Silicon combined with oxygen is abundantly distributed throughout the earth. It is said to form one-sixth part of the crust of the globe and is found pure in nature.

Of what color is pure silicon ?

A dark brown, it exhibits no metallic lustre, even by rubbing. It stains the fingers, and adheres to every thing that comes in contact with it, and when heated in the atmosphere or oxygen gas, it takes fire and burns with the formation of silicic acid.

What are the properties of silicon ?

Silicon is tasteless and destitute of odor ; it is a bad conductor of heat and electricity ; burns neither in the air nor in oxygen.

How is silicon prepared ?

By decomposing the double fluoride of silicon and potassium, by metallic potassium. When this compound is heated in a glass tube with potassium, by means of a spirit lamp, the fluorine combines with the potassium, and the silicon is separated from the mass by washing with water.

By what name is the compound of silicon

and oxygen known ?

Silicic acid, and it is by far the most important of all the compounds of silicon. It exists abundantly in nature in the form of rock crystal, agate, and other analogous substances. It also enters largely into combination with other substances to form the rock masses of the globe.

What are the properties of silicic acid ?

It is infusible alone, except by the power of the compound blow pipe. It dissolves with effervescence in fluohydric acid and in fused carbonate of soda or potash. Most natural waters contain some small portion of soluble silica ; the hot waters of the great geysers in Iceland and of other hot springs, also dissolves large quantities of silica.

Is silica a useful substance ?

Silica is of great use in the arts of glass making, as it is the bases of all vitreous fabrics, including porcelain and Potter's ware from the most common to the richest china.

When silica is deeply colored with iron, what does it become ?

Silex, when deeply colored with iron, becomes amethyst.

Of what origin are agates ?

They are of volcanic origin, and they are silex tinged with different degrees of iron.

Are all kinds of glass composed of silica ?

Every kind of ordinary glass is a silicate ; quartz is an element of glass, and is composed of silex and potash.

- Of what is green glass made ?

Green glass is made of impure materials, such as river sand which contains iron, and the most common kind of pearlash. The green color is owing to the impurities in the ashes, but chiefly to oxide of iron.

Of what is plate glass composed ?

Plate glass is composed of the purist materials, and is used for looking glasses.

Of what is flint glass made ?

Flint glass consists of about three parts of fine sand, two of red lead, and one of pearlash with small quantities of nitre, arsenic and manganese.

How may agates and many of the precious stones be tested ?

Agate, chalcedony, and carnelian, may be tested with glass ; if it will scratch them they are not real.

## **PART IV.**

# **METALS**

## **LECTURE I.**

### **GENERAL PROPERTIES OF METALS.**

Do metals constitute an important class of substances?

They are the most important of all substances.

How many distinguishing properties have metals?

Three, 1st They conduct caloric and electricity.

2d. They do not transmit light, and

3d. They have a metallic lustre, and every substance in which these characters are found, may be regarded as a metal.

What is the number of metals at present known to chemists?

Forty-eight.

Are there many that exist in a pure state?

There are about twenty-nine that can remain without being united to other substances

Mention some of the most important.

The most important of metals are :

|           |            |          |
|-----------|------------|----------|
| Iron,     | Arsenic,   | Silver,  |
| Lead,     | Manganese, | Mercury, |
| Copper,   | Platinum,  | Bismuth, |
| Zinc,     | Gold,      | Cobalt,  |
| Antimony, |            |          |

Do they differ in their properties?

They differ in the following properties :

1. Specific gravity. Great specific gravity was formerly considered as a distinctive character of the metals, there was none known less than six times heavier than water, previous to the decomposition of the alkalies. Potassium and soda are so light that they float upon the surface.

Which is the heaviest of all known substances ?

Platinum.

What is the second property in which they differ ?

2 Malleability.

What is meant by malleability ?

Malleability is a property which permits the metals to be extended under the hammer.

Which is the most malleable of all metals ?

Gold surpasses all metals in malleability; one grain may be extended so as to cover fifty-two square inches of surface. Iron is less malleable, and zinc still less.

What is the third property in which they differ?

### 3. Ductility.

When are metals said to be ductile?

When they are capable of being drawn out into wire

Which of the metals are the most ductile?

Gold, silver, platinum, iron and copper, are the most ductile.

Do the metals differ in hardness?

Metals differ from each other considerably in hardness.

Do they in structure.

Many of the metals have a crystalline structure; some are fibrous, as zinc; others compact; as lead.

Do they differ in their fusibility?

All metals are solid, at the common temperature of the atmosphere; but the point of fusion in the different metals varies exceedingly.

Are metals volatile?

Many of the metals are volatile of which mercury, arsenic, tellurium, &c., are examples being volatile below red heat.

What is meant by the volatility of a metal?

The tendency which metals have to fly off, or their being capable of conversion into vapor. Platinum has been reduced to vapor.

Are the metals elementary or compound bodies?

The metals are generally considered as elementary bodies?

How are metals found in nature?

They are rarely found in their simple or pure state; but when they are thus found, they are said to be in a native state.

How are metals generally found?

Metals are generally found in the state of oxides, sulphurets, and carbonates, they are then called ores, and when found in combination with other bodies, especially with oxygen and sulphur, they are then said to be mineralized.

How are metals obtained from the ores?

The metals are obtained from the ores, by various processes, such as sorting, stamping, washing, roasting, smelting and refining.

By what name has the process of determining the purity of the metals sometimes been termed?

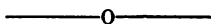
The art of assaying.

What is the process of assaying?

The general process consists in selecting specimens, in equal portions, of those which appear to be the richest, the poorest, and those of medium value, and reduce them to coarse powder; it is then washed, in order to carry off any earthy or stony matter. It is then



roasted in a shallow earthen vessel under a muffle, to expel the volatile principles. The assaying of the precious metals is usually confined to ascertaining the quantity of gold or silver in any alloy or compound.



## LECTURE II.

## ALLOYS.

What is meant by an alloy?

The union of a metal with one or more metals, is termed an alloy.

## ALLOYS OF COPPER.

Of what is bronze an alloy?

Bronze is an alloy of copper, with about eight or ten per cent of tin.

Of what is bell-metal an alloy?

Bell-metal is an alloy of 11 parts of tin and 100 of copper.

Of what is brass an alloy?

Brass is an alloy of four parts of copper to one of zinc.

Of what is Dutch gold an alloy?

Dutch gold is an alloy of copper and zinc.

Of what is German silver an alloy?

German silver is an alloy of copper, zinc and nickel.

Of what is Brittania metal an alloy ?

Brittania metal is an alloy of tin, with lead, copper, antimony, &c.

Are the alloys of copper numerous ?

Copper forms many valuable alloys.

#### ALLOYS OF LEAD.

Of what is solder an alloy ?

Solder is an alloy of two parts of tin and one of lead.

Of what is pewter an alloy ?

Pewter is an alloy of tin and lead.

Of what is lead shot an alloy ?

Lead shot is an alloy of lead and arsenic.

Of what is type-metal an alloy ?-

Three parts of lead to one of antimony constitutes the substance of which types for printing are made.

#### ALLOYS OF SILVER.

Is silver capable of uniting with other metals ?

Silver unites with most of the metals, it may contain a larger quantity of copper without losing its white color.

For what is an alloy of silver and brass used ?

An alloy of brass and silver is used as solder for silver.

With what is silver usually alloyed in commerce?

Silver is alloyed with a little copper, in order to increase its hardness. With steel, it forms an alloy used in cutlery; with copper, it forms the silver plate and coin which is the most useful of its alloys; with mercury, it forms an amalgam, sometimes employed for plating copper.

#### ALLOYS OF GOLD.

Does gold form many alloys?

Gold forms alloys with most of the metals. With tin it forms a whitish brittle alloy, with lead it forms a very brittle alloy, and with copper it forms the alloy used for standard gold, which is perfectly malleable and ductile; harder than pure gold, and resists wear better than any other alloy, except that of silver.

How many carats fine is gold when unalloyed?

Gold when perfectly pure is said to be 24 carats fine.

What is the standard "gold coins of the United States and Great Britain."

The standard gold coin contains one-twelfth part of an alloy, and is said to be 22 carats fine,

How is gilding on copper performed?

By means of an amalgam of gold and mercury.

How is gilding on brass performed?

An amalgam composed of one part of gold,

and eight of mercury is employed in gilding brass.

Do the alloys resemble the metals, in many of their physical properties?

They do. 1st. They are opaque. 2d. They are good conductors of electricity. 3d. They possess a metallic lustre. 4th. They are more or less crystalline in their structure.

How is the hardness of metal increased?

By its being alloyed.

Is the fusibility of metals increased by being alloyed?

They are; thus pure platinum, which cannot be completely fused in the most intense heat of a wind furnace, forms a very fusible alloy with arsenic.—BECK

What is meant by amalgams?

The term amalgam is applied to compounds of mercury with other metals.

Are amalgams solid or liquid?

Amalgams may be formed so as to be either solid or liquid.

How may a solid amalgam be formed?

Quicksilver unites with potassium when agitated in a glass tube with that metal, forming a solid amalgam.

For what is an amalgam of tin and mercury used?

Silvering mirrors.

## LECTURE III.

MM

### CLASSIFICATION OF METALS.

How are the metals divided?

The metals may be divided into two great classes:—

CLASS I. Metals which by oxidation, yield alkalies and earth.

CLASS II. Metals, the oxides of which are not alkalies or earths.

Into what is the first class of metals divided?

Class 1 is divided into three orders, VIZ:

Order I, Metallic bases of the alkaline earths are three in number:—Potassium, Sodium, Lithium.

Order 2, Metallic bases of the alkaline earths are four in number:—Barium, Strontium, Calcium, Magnesium.

Order 3, Metallic bases of the earths are five in number:—Aluminum, Yttrium, Zirconium, Glucinum, Thorium.

Into how many orders are the second class of metals divided?

Class two is divided into three orders.

Order 1, Metals which decompose water at red heat are seven in number:

Manganese, Cadmium, Cobalt,

Iron,  
Zinc,

Tin,

Nickel,

Order 2, Metals which do not decompose water at any temperature, and the oxides of which are not reduced to the metallic state by the sole action of heat :—

|             |            |           |
|-------------|------------|-----------|
| Arsenic,    | Columbium, | Bismuth,  |
| Chromium,   | Antimony,  | Titanium, |
| Vanadium,   | Uranium,   | Copper,   |
| Molybdenum, | Cerium,    | Lead,     |
| Tungsten,   |            |           |

Order 3, Metals, the oxides of which are decomposed by red heat, are eight in number

|          |            |          |
|----------|------------|----------|
| Mercury, | Platinum,  | Osmium,  |
| Silver,  | Palladium, | Iridium. |
| Gold,    | Rhodium.   |          |

## • METALS OF THE FIRST CLASS.

### METALLIC BASES OF THE ALKALIES.

#### ORDER 1. POTASSIUM.

When, and by whom was potassium or kali-um, discovered ?

Davy discovered it in the the year 1807.

By what process did he obtain the metal ?

Sir H. Davy slightly moistened hydrate of potassa, then subjected it to the action of a powerful battery ; the oxygen of both the wa-

ter and potassa passed over to the positive pole ; while the hydrogen of the former, and metallic potassium appeared at the negative. By this process, however, the metal is obtained in small quantities only

Who invented the method by which a larger supply may be obtained ?

Gay, Lussac, and Thénard.

In what did their process consist ?

In bringing the fused hydrate of potassa into contact with turnings of iron, heated to whiteness in a gun barrel. The iron attracts the oxygen from the alkali, and its metallic base is disengaged.

How did M. Curandán prepare potassium ?

By mixing dry carbonate of potassa with half its weight of powdered charcoal, and exposing this mixture contained in a gun barrel, or spheroidal iron bottle, to a strong heat.

What are some of the properties of potassium ?

It is a soft malleable solid, yielding to the pressure of the fingers; like wax: of a metallic lustre, similar to mercury in color.

What is the most remarkable property of potassium ?

Its affinity for oxygen. It oxydizes rapidly in the air or oxygen gas ; but if a piece be thrown upon water, it will decompose it rapidly, disengaging so much heat that the potassi-

um takes fire and burns with a beautiful purple flame.

Has there been any experiment performed?

There has, take a piece of potassium, wrap it up in a small piece of paper, and introduce it quickly into a glass test tube, inverted in a small vessel of infusion of blue cabbage, the tube being filled with the same liquid. The metal will immediately rise to the top, and the moment the water reaches it through the paper part of it will be decomposed, the oxygen combining with it and forming potassa, which changes the blue of the infusion to a green; while an equivalent portion of hydrogen gas is found in the tube, and may be inflamed by a lighted taper. But, perhaps, the most striking illustration of the deoxidizing power of potassium is exhibited by its action on carbonic acid gas; it takes fire, and by uniting with its oxygen forms potassa, while the liberated carbon is deposited in the form of charcoal.—Beck.

Does potassium inflame in chlorine gas?

Potassium inflames spontaneously in chlorine gas, and burns with great brilliancy, forming chloride of potassium.

Has potassium a strong affinity for chlorine?

It has a stronger affinity for chlorine than for oxygen, as its oxides are decomposed by chlorine gas.

How is the potash of commerce obtained?

It is obtained chiefly by evaporating the lye



of wood or vegetable ashes.

What is the hydrate of potash ?

The hydrate of potash is a white solid, with a crystalline fracture. It has a great avidity for moisture and is soluble in half its weight of water.

What are some of the uses of potassa ?

Potassa being a very powerful alkali, is of great use in chemistry and the arts, it also forms the basis of most soaps, and the crude potash is used for making glass.

What are the tests for potassa ?

Potassa may be distinguished from all other substances by the precipitates thrown down from its salts in solution.

Can you give an example ?

Take any of the salts of potassa in solution, and pour into them tartaric acid ; a white precipitate will be thrown down which is called the bitartrate of potassa.

Are there any compounds of potassium ?

There are several, the Peroxide, Bromide, Fluoride, and Hyduret of potassium.

Are there any sulphurets ?

There are five sulphurets which depend upon the quantity of sulphur.

## LECTURE IV.

### THE ALKALIES. Order 1.

#### SODIUM AND LITHIUM.

By whom was sodium discovered ?

Sir H. Davy, in the year 1807.

Where is it found ?

The earth and sea abound in common salt. In many places it is found in immense beds in the interior of the earth, from which it is broken up and dug out. It is also found in almost every spring of water, in every soil and in every plant.

Is it much used in the arts ?

Salt is necessary to the life of animals and plants, without it, no complete digestion of the food could take place. It is also used for preserving animal and vegetable substances, it having the power of preventing chemical decompositions ; and wood for the purpose of building is rendered more durable by being impregnated with salt.

What are some of the properties of sodium ?

Sodium is a solid, at ordinary temperatures, has the lustre and general appearance of silver. It possesses the property of welding, fuses at  $200^{\circ}$ , and rises in vapor at a full red heat.

When exposed to the air, it soon tarnishes, though less rapidly than potassium.

What are some of the uses to which sodium is applied?

It is used extensively in the manufacture of hard soaps, and for culinary and medicinal purposes.

How is the peroxide of sodium obtained?

By heating sodium to a redness, in an excess of pure oxygen. It has an orange color, but no acid or alkaline properties.

What is said of the hydrate of soda?

"Soda, (or rather the hydrate of soda), is distinguished from other alkaline bases by the following characters;—1st, It yields with sulphuric acid, a salt, which by its taste and form is easily recognized as Glauber's salt, or sulphate of soda. 2nd, All its salts are soluble in water, and are not precipitated by any reagent. 3rd, On exposing its salts, by means of platinum wire, to the blow pipe flame, they communicate to it a rich yellow." *Turner*.

What is the chloride of sodium?

The chloride of sodium is commonly known in all countries as common salt; it is found in nature in rock salt and in salt springs. More than 2,000,000 bushels are annually manufactured in the town of Salina, New York, alone.

What are some of the uses of chloride of sodium.

It is used for bleaching, and for removing

the odors which arise from drains, sewers, and all kinds of animal matter in a state of putrefaction. It is employed in surgical practice for destroying the fetor of malignant ulcers.

## LITHIUM.

Is lithium a metal?

It is a white colored metal, like sodium.

By whom was it discovered?

Lithium was first obtained from lithia, by Sir H. Davy, by means of galvanism; but it oxidized so rapidly, that he was unable to examine its properties.

How is lithia distinguished from potassa and soda?

By its power of saturating a greater quantity of any acid. The chloride of lithium dissolves in alcohol, and the solution burns with a red flame. "The salts of lithia, when heated platinum wire before the blow pipe, tinge the flame of a red color." *Turner.*

## LECTURE V.

### FIRST CLASS OF METALS.

*Order 2—Metals which with oxygen, form alkaline earths.*

Barium, Strontium, Calcium, Magnesium.

By whom was barium discovered?

Barium was first obtained by Sir H. Davy, in 1808.

What are some of the properties of barium?

It is of an iron gray color, with little lustre. It attracts oxygen from the atmosphere and from water, and crumbles into a white powder, which is the protoxide of barium.

How may the peroxide of barium be obtained?

By heating baryta in oxygen gas.

What is the process by which barium is obtained?

It consists in forming carbonate of baryta into a paste with water, and placing a globule of mercury into a little hollow made in its surface. The paste was laid upon a platinum tray which communicated with the positive pole of a galvanic battery of 100 double plates, while the negative wire was brought into contact with the mercury. The baryta was decomposed, and

its barium entered into combination with mercury. This amalgam was then heated in a vessel free from air, by which means the mercury was expelled, and barium obtained in a pure form. *Turner.*

## STRONTIUM.

Of what is strontium the base

It is the metallic base of strontia, an alkaline earth, which so nearly resembles barzta, that it has frequently been considered the same substance,

By whom was the existance of strontia established ?

Dr. Hope of Edinburgh, in the year 1792. He extracted what he considered as a new earth, from the strontianites, a mineral found in the lead mine of Strontian, in Argyleshire, Scotland ; and hence the origin of the term strontites or strontia, by which the earth itself is designated.

By whom was the base of strontia discovered ?

Sir H. Davy discovered it by a proces analogous to that described for procuring barium.

How may the hydrate of strontia be obtained ?

Strontia, when mixed with water, slacks causing intense heat, and forming a white powder, to which the name hydrate of strontia may

be applied.

Where is the sulphate of strontium found ?

On the shores of Lake Erie, at Detroit, and in some other parts of the Continent. The red lights used in fire works, owe their color to nitrate of strontia, with which they are prepared ?

How may the sulphuret of strontium be formed ?

By fusing strontia and sulphur in a green glass tube, or by exposing the powdered sulphate to a red heat with charcoal.

#### CALCIUM.

When and by whom was calcium first obtained ?

Calcium was first obtained by Sir H. Davy, in the year 1808, by exposing lime to the action of a voltaic battery.

What are some of the properties of calcium ?

It is a yellowish white metal, resembling silver in its appearance, and which, when exposed to the air, and gently heated, is oxydized and converted into lime.

What is lime ?

Lime is a brittle, white, earthy solid.

How is lime water prepared ?

By mixing hydrate of lime with water, and agitating the mixture then set it aside, in a bottle well corked, until the undissolved parts

shall have subsided.

Where is it found ?

It is found very abundantly in nature, constitutes a part of the teeth and bones of animals, enters into many vegetable combinations, and forms a large portion of the rocky strata of the earth.

Is it found pure in nature ?

It is not, but is obtained by calcination of carbonate of lime, which exists in various forms as limestone, chalk, marble, &c.

What are some of the uses of lime ?

Lime is very extensively used in the preparation of mortar for building, for whitening walls, and as an antacid in medicine.

How is lime obtained for purposes of commerce ?

Lime is obtained sufficiently pure for purposes of commerce, by calcining the common limestone in limekilns.

How is the milk or cream of lime made ?

By mixing with the hydrate a little water, so as to give it a liquid form, of the consistency of thin paste.

#### MAGNESIUM.

By whom was magnesium discovered ?

Sir H. Davy discovered and obtained it in small quantities, but M. Bussy obtained it in



greater abundance by the action of potassium on chloride of magnesium.

What was the process by which it was obtained?

Five or six pieces of potassium, of the size of peas, were introduced into a glass tube, the sealed extremity of which was bent into the form of a retort, and upon the potassium were laid fragments of chloride of magnesium; the latter being then heated to near its point of fusion, a lamp was applied to the potassium, and its vapor transmitted through the mass of heated chloride. Vivid incandescence immediately took place; and on putting the mass, after cooling, into water, the chloride of potassium, with undecomposed chloride of magnesium, was dissolved, and metallic magnesium subsided. *Turner.*

What are some of the properties of magnesium?

It is a white powder having neither taste nor odor, it is frequently used in medicine.

## LECTURE VI.

### *Order 3.—Metallic bases of the earths.*

#### ALUMINUM.

What is aluminum ?

Aluminum is the metallic base of the earth alumina.

How did Sir H. Davy attempt to decompose alumina ?

By galvanic power, but failed in the attempt.

Where is alumina found ?

In nature, in great abundance, and it is sometimes found beautifully crystallized in gems, such as the ruby and sapphire; and it is a constituent of the oldest rocks, and of the most recent alluvial depositions.

What are some of the properties of alumina ?

It has neither taste nor smell, and is quite insoluble in water. *Can not be dissolved*

Does alumina possess both the properties of an acid and an alkali ?

It does

How can you show that alumina possesses the properties of an acid.

It unites with alkaline bases, thus proving that it possesses the property of an acid.

How is it shown that it possesses the property of an alkali?

By its uniting with acids to form salts.

What are the two distinguishing characteristics of alumina?

1st. It is separated from acids, as a hydrate, by all the alkaline carbonates, and by ammonia. 2d. It is precipitated by potassa or soda, but the precipitate is commonly redissolved by an excess of alkali.

How is the sulphuret of aluminum formed?

By dropping a piece of sulphur on aluminum when strongly incandescent. *glowing with heat*

How is the phosphuret of aluminum formed?

By heating the aluminum to redness, in contact with the vapor of phosphorus.

From what does aluminum derive its name?

Aluminum, the Latin name of alum, of which it is the basis.

How is pure alumina obtained?

From alum, sulphate of alumina and potassa.

#### GLUCINUM.

When was glucinum obtained?

In the year 1728, by Wohler.

When was the oxide of glucinum, or glucina obtained?

Oxide of glucinum, or glucina, was discovered by Vanquelin in the year 1795.

Where has glucinum been found?

In three rare minerals, the beryl, euclase, and emerald.

#### YTTRIUM.

How is yttrium obtained?

From yttria, a sweedish mineral.

When was yttrium discovered?

Yttrium was discovered in the year 1795, by Professor Gadolin, in a very rare mineral, at Ytterby, in Sweden, from whence its name.

What are some of its properties?

It is of a white color, combines with sulphur, selenium and phosphorus.

#### THORIUM.

Where is thorium found?

Thorium is obtained from a mineral found in Norway.

How is this metal procured?

By the action of potassium on the chloride of thorium; decomposition being accompanied by a slight detonation. On washing the mass, thorium is left in the form of a heavy metallic powder, of a deep leaden gray color; and when pressed in an agate mortar, it acquires metallic lustre, and an iron gray tint.—TURNER.

How is the carbonate of thorina formed?

By heating thorina with sugar.

#### ZIRCONIUM.

By whom was zirconium discovered?

Berzelius in 1824.

What are some of the properties of zirconium?

The substance exists in a powder black as charcoal, which may be boiled in water, without being oxidized; it is a non-conductor of electricity, and takes fire when heated in the open air, at a temperature below a red heat.

Where are crystals of zirconia found?

Crystals of zirconia are now found in different parts of our own country; in Buncome county, N. C.; at Easton, Pa.; and in Monroe and Haddam, in the State of Connecticut.

## LECTURE VII.

SECOND CLASS OF METALS, THE OXIDES OF WHICH  
ARE NOT ALKALIES OR EARTHS.

*Order 1.—Metals which decompose water at  
red heat.*

X MANGANESE.

How is manganese found in nature ?

Manganese is a metal of a dull whitish color; it is never found native in the metallic state, the substance known in the arts by this name being an impure oxide.

By whom was manganese discovered ?

“The black oxide of manganese was discovered by Scheele, in the year 1774, as a peculiar earth. Gahn subsequently showed that it contained a new metal, which he called manganesium, a term since applied to the metallic base of manganesia. and for which the words manganesium and manganum have since been applied.”—TURNER.

What are some of the properties of manganese ?

It is very hard and brittle, soon turns to a dark oxide on exposure to the air; and absorbs oxygen with rapidity when heated to redness in open vessels.

What are some of the uses of manganese ?

It is employed in the arts, in bleaching, pottery, and glass making.

How may the protoxide of manganese be formed ?

Protoxide of manganese, as shown by Berthier may be formed, by exposing the peroxide, sesquioxide, or red oxide of manganese, to the combined agency of charcoal and white heat.

Does manganese form alloys with any of the metals ?

According to Berzelius, manganese combines with silicium, gold, silver, copper and iron. The alloy of manganese and iron is whiter than iron.

#### IRON.

Is iron abundant in nature ?

It is very extensively diffused in nature, but is rarely found pure. It enters also into combination with plants, and circulates in the blood of animals. It is the only metal which is not injurious to health and which forms a never failing constituent of the body, especially of the blood.

Is iron a useful metal ?

It is one of the most useful of metals, and in the arts it is applied to innumerable uses, such as the construction of bridges, railways, cannons, &c. Small ships, steam engines,

watch-springs and magnets have been made of iron. It is the ladder upon which the arts and trades have mounted to such an extraordinary height. It is the bridge upon which we now glide over mountains and vallies with the rapidity almost of magic.

When was iron first discovered ?

It appears to have been known from the earliest ages of the world. Moses mentions it in his writings, although the exact time of its discovery has never been ascertained.

What are some of the properties of iron ?

It is malleable, ductile, and in a pure state is very fusible.

Can iron be acted on by a magnet ?

It is strongly attracted by the magnet, and acquires itself the magnetic power, when in the form of steel it retains its magnetism.

Does iron unite with carbon ?

It does in several proportions, but the most important of these combinations are steel and plumbago.

What will be the result if a drop of acid fall upon steel ?

The carbon will be attracted by it, and a black spot will appear.

What is cast iron, and for what is it used ?

Cast iron is a compound of carbon and iron, and it is very extensively used in the construction of machinery, in the making of stoves, hollow-ware nails, &c



What are some of the properties of cast iron ?

Cast Iron is fusible at a glowing white heat, is brittle and can neither be forged nor welded.

How many kinds of cast iron are there ?

There are two kinds of cast iron, known as gray and white iron. The gray is almost black, has a granular texture, and admits of being filed and bored. The white is of a silvery whiteness, and not so hard, as not to be acted upon by steel instruments.

From what is steel generally prepared ?

Malleable iron.

How is steel made from iron ?

The iron is surrounded with charcoal and placed for several days, in a furnace intensely heated ; the carbon unites with the iron and is called steel.

What are some of the uses of steel ?

Many instruments are made of steel, such as forks, penknives, saws, axes, &c.

#### ‡ ZINC.

Has the existence of zinc been long known ?

Zinc has long been known in the East, India and China, but it was first distinctly noticed in the sixteenth century, by Paracelsus, under the name of zinctum. Henchel was the first who obtained it from calamine in the the year 1721, and it has recently been discovered in Europe.

By what other name has zinc been called ?

Spelter, and it is obtained either from "calamine, the native carbonate of zinc, or from the native sulphuret, the zinc blende of mineralogists."

What are some of the uses of zinc ?

It is extensively used in the arts, for the construction of voltaic instruments, covering buildings, the manufacture of kitchen utensils, and water pipes. It is harder yet lighter than lead, cheaper than copper, and less liable than iron to be destroyed by air and water.

How is it usually found in commerce ?

In the form of sheets, which are so brittle that they may be broken by the hammer into small pieces.

Can you give an experiment ?

When polished zinc remains exposed to the air for some time, it loses its lustre, and is covered with a gray film, which consists of zinc combined with a small quantity of oxygen, and is called suboxide of zinc.

What are some of its properties ?

This metal is of a bluish white color, with a strong metallic lustre and lamellated texture. It is hard and brittle, but between the temperatures of  $210^{\circ}$  and  $300^{\circ}$  Fahr. it is malleable and ductile, and in this state it is rolled out into plates.

## LECTURE VIII.

### METALS.

SECOND CLASS OF METALS, THE ORDER OF WHICH  
ARE NOT ALKALIES OR EARTHS.

*Order 1st,—Metals which decompose water at red heat.*

### CADMIUM.

From what did cadmium derive its name?

From its nearly always being found associated with zinc and it is chiefly distinguished from it, by its malleability when cold.

By whom was cadmium discovered?

Stromeyer, in the year 1818.

By what process did he discover it?

“The ore of cadmium is dissolved in hydrochloric or sulphuric acid in excess. The sulphuret of cadmium is precipitated by hydro-sulphuric acid. Nitric acid decomposes this, and forms a nitrate, which is evaporated to dryness. To a solution of this in water, an excess of carbonate of ammonia is added, and the white carbonate of the oxide of cadmium is precipitated, which, when subjected to a red heat yields a pure oxide.” *Gray.*

How is the metallic cadmium obtained from

the oxide?

By heating it with charcoal.

Who proposed an elegant process for separating zinc from cadmium?

Dr. Wollaston.

How is the solution prepared?

The solution of the mixed metal is put into a platinum capsule, and a piece of metallic zinc is placed in it. if cadmium is present, it is reduced, and adheres so tenaciously to the capsule. that it may be washed with water without danger of being lost. It may then be desolved either by nitric or diluted muriatic acid." *Turner*.

## ↓ TIN

What is the history of tin?

Tin was known to the ancients, in the time of Moses, and was in common use by the Phoenicians. It is supposed they obtained it from Cornwall, England.

Where is tin found?

In India, Germany, Chilli, and Mexico.

What is the process for obtaining tin?

The tin of commerce is obtained from the native oxide by heated charcoal, and in the form of block and grain tin.

What are some of the properties of tin?

It is a white metal, harder than lead, and

produces a crackling sound when bent. It is very malleable, and may beaten into tinfoil leaves ; its odor and taste are peouliar, but it tarnishes on exposure to the air.

What is block tin ?

Tin purified by heat and run into moulds form blocks of great size.

What are tin plates ?

Sheets of iron coated with tin.

From what is tinfoil made ?

The finest tin beaten out with a hammer.

What are some of the uses of tin ?

It is used very extensively in the manufacture of culinary articles, and for roofing houses.

#### COBALT.

What is the origin of the name cobalt ?

It derives its name from Cobalus, an evil spirit, who is supposed to visit mines, impede the operation of the miners, and destroy their lives.

When was cobalt discovered ?

In the fifteenth century.

What are some of the properties of cobalt ?

It is a solid metal, hard, brittle, of a reddish gray color, and weak metallic lustre ; fuses at 130° Wedgewood, and crystalizes when slowly cooled.

Where is cobalt found ?

In nature, in the form of oxide, of sulphate, of arseniate, and in combination with many combustibles, especially with sulphur and arsenic.

What is the zaffre of commerce ?

It is an impure oxide of cobalt, obtained by heating the arseniuret in a reverberatory furnace. When this substance is heated with sand and potassa, a beautiful blue colored glass is formed, known by the name of smalt.

For what is it used ?

It is used in the arts for communicating the blue color to glass, porcelain, and earthenware.

How is sympathetic ink made ?

By dissolving the oxide of cobalt in muriatic acid, diluted with water. Words written with this ink, will be invisible, till brought in contact with the fire, when the writing will appear of a bright blue tint,

Can you give an experiment with India ink ?

Draw the branches of a tree with India ink and put on the foliage with chloride of cobalt. When cold the foliage does not appear, but shows itself on the application of heat. A landscape may be represented in this manner, as wintry or vernal according as the heat is increased or diminished.

What is one of the most important proper-

ties of cobalt ?

That it is highly magnetic.

#### NICKEL.

When was nickel discovered ?

In the year 1751 by Constredt, and the term nickel was applied to the ore, because it looked like copper, but did not yield it.

What are some of the properties of nickel ?

It has a strong metallic lustre, ductile and malleable ; attracted by the magnet. and like iron and cobalt, may be rendered permanently magnetic ; when pure its color is white, but the nickel of commerce is usually of a reddish order.

Does nickel form an alloy with any of the metals ?

It may be alloyed with most of the metals. An alloy of iron and nickel has been found in all the meteoric stones that have been analyzed.

Are there any compounds of nickel ?

There are several, such as the Protoxide, Sesquioxide, Chloride, &c.

## LECTURE IX.

### SECOND CLASS OF METALS.

*Order 2nd,—Metals which do not decompose water at any temperature, and the oxides of which are not reduced to the metallic state by the sole action of heat.*

#### ( ARSENIC.

By whom was arsenic discovered ?

It was first discovered by Dioscorides, who called it sandarac.

Where is it found ?

In nature in small quantities, and it is also found in combination with cobalt and iron.

What are some of its properties ?

It is a very brittle metal, of a crystalline structure, burns with a blue flame and white smoke, giving off a strong odor of garlic, a property which belongs to no other metal, unless it be zinc ; when thus heated in the air, it is converted into the white oxide of arsenic.

What are some of the uses of arsenic ?

It is used in the manufacture of glass, shot, &c.

What is the action of arsenic on the animal economy.

It is well known as one of the most violent



of poisons, and acts not only when taken into the stomach, but also when applied externally to a wound, or inspired as a vapor. A very small quantity of it produces a fatal effect unless antidotes are quickly administered.

Is it ever used for destroying animals?

White arsenic is frequently employed for killing rats and various other kinds of animals.

Is arsenic ever used by physicians?

It is frequently used for medicinal purposes.

#### CHROMIUM.

By whom was chromium discovered?

Vauguelin, a French chemist, in 1797, in a beautiful red mineral, the native chromate of lead.

What are some of the properties of chromium?

It is a metal of a white color, with a shade of yellow, has a metallic lustre, is brittle, and very fusible; it is not changed by air, but absorbs oxygen at a red heat.

How may metallic chromium be obtained?

By exposing its oxide, mixed with charcoal to the most intense heat of a smith's forge.

Does chromium possess any coloring properties?

Many of the gems owe their beautiful tints to the metal chromium. Its acid gives the red color to the ruby; its oxide, the green color to

the emerald.

In what is the chromate of iron found ?

Marble and serpentine. There are some fine specimens of chromate of iron found in the United States.

#### VANADIUM.

From whence did vanadium derive its name ?

Vanadium was so called from Vanadis, the name of a Scandinavian divinity, and was discovered by Sefstrom in 1830.

What are some of the properties of vanadium ?

This metal when obtained by means of potassium, is a heavy black powder with very little lustre ; but when prepared by the decomposition of chloride, it has a white color resembling silver, of a strong metallic lustre, and is extremely brittle. It is not oxidized by either air or water, nor acted on by boiling, sulphuric, muriatic, or hydrofluoric acid ; but it is attacked by the nitric and nitro-muriatic acids, and the solution has a fine dark color.

Where is vanadium found ?

It exists in the iron ore of Taberg, Sweden, and is found in greater abundance in the slag formed for converting the cast iron of Taburg into malleable iron.

From whence does this metal derive its name ?

From the Greek *molublaina*, lead ; this metal was at first confounded with black lead, but is now known by the name of plumbago. It was discovered in 1775.

Has it ever been found pure in nature ?

It has not, and is separated from its ore, the native sulphuret, with considerable difficulty.

What are some of its properties ?

It is a brittle metal, of a white color, and very infusible.

#### TUNGSTEN.

Where was this metal first discovered ?

In Sweden, and in the Swedish language its name signifies heavy stone, from the Swedish words *tungsten*.

How is tungsten obtained ?

By exposing a mixture of tungstic acid and charcoal to a strong heat.

What are its properties ?

It is a very hard, brittle metal, resembling iron in color, and by the action of heat and air, converted into tungstic acid.

#### COLUMBIUM.

When, and by whom was columbium disco-

vered?

In the year 1801, by Hatchett who detected it in a black mineral belonging to the British Museum, supposed to have come from Massachusetts, and from this circumstance applied to it the name of columbium. About two years after the discovery of columbium, a Swedish chemist, named Ekebery, extracted the same substance from the mineral named tantalite. In 1809, Dr. Wollaston proved that tantalite was identical with columbium.

How is columbium obtained?

By heating potassium with the double fluoride of potassium and columbium.

## ANTIMONY.

By whom was antimony discovered?

Basil Valentine, in the fifteenth century.

From what did antimony derive its name?

Antimonk, from its having proved fatal to some monks, to whom it had been administered as a medicine.

Where is antimony found?

It is sometimes found native; but its only ore which is abundant, and from which the antimony of commerce is derived, is the sulphuret.

What are some of the properties of antimo-

ny ?

Antimony has a lamellar chrystalline texture, and a white metallic lustre like bismuth, but far exceeds it in brittleness, for it may easily be rubbed to powder in a mortar, it will tarnish, but not otherwise alter, by exposure to the air.

What are some of the uses of antimony ?

It is much used in type foundrys, to give hardness to the lead, in the alloy called type metal.

Is it ever used for medicinal purposes ?

Antimony is a highly valuable medicine, when used with proper discretion.

## LECTURE X.

### SECOND CLASS OF METALS.

#### *Order 2.—Continued.*

#### URANIUM.

When was uranium discovered?

In the year 1789, by Klaproth, a German.

From what does it derive its name?

The new planet Uranus, the discovery of which took place in the same year.

What are some of the properties of uranium?

This metal, as prepared by Arfwedson, by conducting hydrogen gas over protoxide of uranium heated in a glass tube, is crystalline, of a metallic lustre and reddish brown color; when exposed to the air at common temperature, it does not change; but when heated in open vessels, absorbs oxygen, and is reconverted into the protoxide.

#### CERIUM.

By whom was cerium obtained?

Hisinger and Berzelius, in a rare Swedish mineral called cerite.

Where is cerium found?

In the mineral called allanite, as an oxide, which is very difficult to be reduced to the metallic state.

#### BISMUTH.

Where is bismuth found?

In the earth, in the form of pure ore, of an oxide, a sulphuret and an arseniate.

Is bismuth ever found in crystals?

Native bismuth is sometimes found in crystals, octahedra or cubes. It is also combined with sulphur and oxygen, from which it is obtained by the aid of heat and charcoal.

Can you give an experiment with bismuth?

Heat a piece of bismuth upon charcoal before the blow-pipe; it melts with the ejection of sparks, and volatilizes at a higher temperature with brisk ebullition.

What are some of the properties of bismuth?

It is a metal of a reddish white color, brittle, and not easily oxidized by the air.

Does bismuth enter into alloys with metals?

It does with most of the metals, one of which is the fusible metal, composed of eight parts of bismuth, five of tin, and three of lead.

#### TITANIUM.

When was titanium first recognized as a metal?

In the year 1791, by Mr. Gregor, of Cornwall, and its existence was afterward established by Klaproth, who gave it the name of titanium, after the Titans of ancient fable.

By whom was its properties discovered?

Wollaston, in 1822, who found it in a slag of an iron smelting furnace in South Wales.

In what state is native titanium found?

Native titanium occurs in cubic crystals, whose color and lustre are like burnished copper; and it is so exceedingly hard, that it will scratch rock crystal.

To what use has the oxide of titanium been applied?

To color mineral teeth, in imitation of natural ones, it has also been used in porcelain painting.

#### TELLURIUM.

Where is tellurium found?

Tellurium is a rare metal, found only in small quantities in Transylvania and Connecticut.

By whom was it first discovered

Muller in 1782, but its existence was more fully established in 1798 by Klaproth, who called it *tellurium*, from *tellus*, the earth.

What are some of its properties?

It is a metal of a greyish white color, brit-



tle, very infusible and volatile, and when heated in the air, it burns with a sky-blue flame, edged with green, and is dissipated in grey colored, pungent, inodorous fumes.

With what metals is it capable of uniting?

Oxygen, chlorine, sulphur and hydrogen.

### COPPER.

What is the origin of the name copper?

Copper was known in the earliest ages of the world, and it is said to have been discovered in the isle of Cyprus, and dedicated in heathen mythology, to the worship of the god Venus; hence the alchemists termed this metal Venus.

What is the latin name?

Copper or cuprum, which is derived from Cyprus.

How is copper found in nature?

It is found pure in native masses, in the north-western part of this Continent, in octahedral crystals. It also occurs in various states of combination, as the oxide, chloride, sulphuret, carbonate, sulphate, arseniate and phosphate.

How is copper distinguished from all other metals?

By having a red color, titanium excepted?

What are some of its properties?

It is very malleable, ductile and tenacious, and is the most sonorus of all metals. It receives a considerable lustre by polishing.

Does copper change much by being exposed to the atmosphere?

It undergoes but little change in a perfectly dry atmosphere; but when exposed to air and moisture, it becomes thinly coated with a green, which is carbonate of copper.

What are some of the uses of copper?

It is used to form various culinary and manufacturers vessels, for pumps, water pipes, engraver's plates, and for coining.

Is it ever poisonous?

When combined with acids or oxygen, it becomes more or less poisonous, therefore, culinary vessels of copper should never be used except when perfectly clean or well tinned.

Are the alloys of copper numerous?

Copper forms many valuable alloys, among which is brass, which consists of copper and zinc

Where are copper mines found?

In many countries, but those of Sweden are said to furnish the purest copper of commerce.

Can copper be formed into any shape?

It can, but it will not bear more than a red heat. The bolts of copper used for ships are made with the hammer.

In what does the art of tinning copper consist?

In covering that metal with a thin layer of tin, in order to protect its surface from rusting. For this purpose pieces of tin are placed upon a well polished sheet of copper, which is heated sufficiently for fusing the tin. As soon as the tin liquefies, it is rubbed over the whole sheet of copper; and if the process is skillfully conducted, adheres uniformly to its surface.

Does the two metals combine?

They do not actually combine, yet the adhesion is certainly owing their mutual affinity.

#### LEAD.

What is the history of lead?

Lead was well known to the ancients; it received the name of Saturn from the alchemists, because as this deity, according to mythological fable devoured his children, so lead, in the process of cupellation, absorbs or devours most of the metals.

What is its latin name?

Plumbum.

What is said of it as a native production?

Native lead is an exceedingly rare production, but in combination with sulphur it occurs in large quantities.

From what is the lead of commerce extracted?

The native sulphuret, the *galena* of mineralogists. The lead obtained from from galena, sometimes contains so much silver, that the ore is worked for the silver it contains, rather than for the lead.

In what should it be dissolved to obtain it in a state of perfect purity?

Nitric acid, and the solution should be evaporated and crystallized several times.

What are some of the properties of lead?

It has a bluish-gray color, with a bright lustre. which becomes quickly tarnished on exposure to the air. It is sufficiently malleable to allow of its being heated into very thin leaves, and it may be drawn into wire, which has less tenacity, however, than most other metals. It absorbs oxygen quickly at high temperatures and when fused in open vessels, a grey film is formed upon its surface, which is a mixture of metallic lead and protoxide; and when strongly heated it is dissipated in fumes of the protoxide. Many kinds of spring water, owing to the salts which they contain, do not corrode lead; and hence, though intended for drinking, it may be safely collected in leaden cisterns.

What are some of the uses to which lead is applied?

It is used for covering of roofs, for acqueducts, for lining cisterns, for weights, bullets, shot, &c.

Can lead be alloyed with any other metals?

Tin alloyed with antimony, copper and bismuth, form the best kind of pewter. An alloy of antimony and lead constitute the substance of which types for printing are made.

## LECTURE XI.

### SECOND CLASS OF METALS.

*Order 3rd,—Metals, the oxides of which are decomposed at red heat.*

#### MERCURY

Has mercury been long known ?

This metal was well known to the ancients. It was named by the alchemists from the planet mercury.

Where is it found ?

The principal mines from which it is obtained, are those of Idria, in Carolina ; and Almaden, in Spain : but it is also found in Italy, South America, in the East Indies, in Siberia, and in very small quantities in England and France.

Is mercury ever found native ?

It occurs native, or in combination with sulphur, forming cinnabar, from which the metal may be separated by distillation with quicklime or iron filings.

How is mercury distinguished from all other metals ?

By its being fluid at the ordinary temperature, and on this account it is used in many philosophical and chemical instruments.

What are some of its properties?

It has a tin white color and strong metallic lustre, becomes solid at the temperature of  $39^{\circ}$  or  $40^{\circ}$  below zero, and in congealing, evinces a strong tendency to crystallize in octahedrons. It contracts greatly at the moment of congelation, for while its density at  $47^{\circ}$  is 13, 55, that of frozen mercury is 15, 62. When solid it is malleable, and may be cut with a knife. At  $662^{\circ}$  it enters into ebullition, and condenses again on cool surfaces into metallic globules.

How is it generally brought to the United States?

In strong iron bottles, and when first taken from these bottles, it is said to be generally very pure. When pure it is not tarnished in the cold by exposure to air and moisture, but if it contains other metals, the amalgam of those metals oxydizes readily and collects a film upon its surface.

What is an amalgam?

An alloy of mercury with other metals is denominated an amalgam.

What are some of the uses of mercury?

Mercury is made use of for many important purposes, in medicine, in the laboratory and in the arts; it is also useful for the construction of thermometers and barometers, and for the mercurial bath, to enable the chemist to collect and transfer gases that are absorbed by water, and in union with various other substances it

constitutes the basis of many important medicines.

For what use is a solid amalgam of tin employed?

In making looking glasses.

With what metals does mercury readily amalgamate?

Gold, silver, tin, lead, and zinc,

What is the process by which looking-glasses are silvered?

“In the silvering of plain looking-glasses, a flat, horizontal slab of stone is used as a table. This is smoothly covered with paper, and a sheet of tin-foil, equal to the size of the glass is extended over it, a quantity of mercury is then laid upon the tin-foil and immediately spread over it with a roll of cloth, or a hare's foot. Afterwards as much mercury as the surface will hold is poured on. While this mercury is yet in a fluid state, the plate of glass is slid on at the edge of the table, so as to pass over the tin foil, driving the superfluous moisture before it. In this way any bubbles of air, and particles of dust, are prevented from getting between the glass and the metal, and an uninterrupted coating is formed. In order to force out the remaining liquid mercury, the glass is placed in a sloping position, to allow the mercury to drain off; after which heavy weights are placed upon the glass, and suffered to remain for some time. The portion which is left amalgamates with the tin, and forms a permanent re-



flecting surface, the smoothness and perfection of which depends upon the degree of regularity and polish which the glass possesses." *Bigelow's Technology*.

What is the history of silver?

This metal was known to the ancients. It is frequently found pure in a native state, though often sulphuretted, and alloyed with other metals, such as gold, copper, antimony and arsenic.

What name did the alchemists give this metal?

Diana or luna (the moon) probably on account of its white lustre.

What are some of its properties?

Silver is of a brilliant white color, it is malleable, and so ductile, that it is capable of being drawn into very fine wire. It is oxidated by the air, and is very soft when pure so that it may be cut with a knife. Pure silver does not rust by exposure to air and moisture, and when fused in open vessels it absorbs oxygen in considerable quantities amounting sometimes to 22 times its volume.

How is it extracted from the ore?

By two distinct processes, viz :—cupellation and amalgamation.

What are some of the uses of silver?

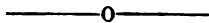
It is used in every country for many important purposes, for coining and for many ornaments of utility.

With what is silver alloyed to increase its hardness?

Silver is always alloyed with copper to increase its hardness, and render it less liable to be worn by use.

Is silver capable of forming any alloys?

It forms an alloy with most other metals, an alloy of silver and brass is used as a solder for silver.



## LECTURE XII.

### SECOND CLASS OF METALS.

*Order 3rd,—Metals, the oxides of which are decomposed at red heat.*

#### GOLD.

What is the history of gold?

Gold appears to have been known from the earliest ages of antiquity. It has hitherto been found only in the metallic state.

Where is it found?

Gold is found in almost every country ; but

but the most extensive mines are those of South America, Mexico, Peru and Hungary. It is also found in the United States, particularly in North Carolina, Virginia and Gorgia. It is sometimes found in primary mountains, but more frequently in alluvial depositions, especially among the sand in the beds of rivers, having been washed by water out of disintegrated rocks in which it originally existed. It occurs massive, capillary, in grains, and crystallized in cubes and octahedrons.

What are some of the properties of gold?

It is a metal of a yellow color, capable of receiving a high lustre by polishing, but is inferior in brilliancy to steel, silver and mercury, but is the most ductile of all metals.

Can you give an illustration of its ductility?

It may be beaten out into extremely thin leaves, and a single grain of gold may be drawn out into a wire five hundred feet in length.

What are some of the uses of gold?

Gold is employed for coin, and in the manufacture of a great many articles, which are chiefly ornamental. In the United States both gold and silver coin are melted down for use in the arts, but in many countries it is forbidden by law.

Does air change the color of gold?

It may be exposed for ages to air and moisture, without being oxidized.

Does gold form an alloy with any of the metals ?

It does usually with silver and copper.

What does it become when united with iron ?

Magnetic.

Does mercury unite with gold ?

It readily unites with it, and a gold ring will become white by mere contact with mercury.

How is the fineness or purity of gold expressed ?

By numbering the parts of gold which it contains. It is supposed to consist of 24 carats fine when perfectly pure or unalloyed. If gold is said to be 18 carats fine, it is understood that the mass consists of three-fourths ( 18 parts of gold, and one-fourth—6 parts ) of alloy.

How can you test gold ?

The most simple mode of testing gold is to rub some of it off upon a black flint slate, and apply to the mark a drop of aqua-fortes. If the gold is pure the yellow stroke remains unchanged, but if alloyed it partly disappears ; if it is only an imitation of gold, for instance, tombac, it entirely disappears.

What is the standard gold coin of the United States and Great Britain ?

22 carats fine, is generally considered the standard.

How is water gilding prepared ?

Mercury and gold combine, and form an amalgam which is employed in gilding. It is applied to the surface of silver, and the mercury driven off by heat.

Can you give me an experiment of gilding ?

Dip a dry test-tube into a diluted solution of gold, so as to moisten the bottom of it, then heat it over the flame of a spirit lamp and it will become gilded—a proof that gold has only a feeble affinity for chlorine, since it releases it at a mere gentle heat.

Can you give me another instance ?

Drop some of the solution of gold upon blotting paper, let it dry ; then hold it by means of a wire over the flame of a spirit lamp and you obtain finely divided gold mixed with the ashes of the paper as a coherent loose mass. If you rub this for some time upon a bright silver spoon, with a soft cork which has been dipped in salt water, the silver becomes gilt, or cold gilding as it is generally denominated.

#### PLATINUM.

What is the history of this metal ?

This valuable metal was first discovered by Mr. Wood, in 1741, near the river La Plate, in South America, but no description of it appeared until 1749.

How is this metal found ?

It occurs only in the metallic state, associated or combined with various other metals, such as copper, iron, lead, titanium, chromium, gold, silver, palladium, rhodium, osmium and iridium.

Where is it chiefly found?

In Brazil, Peru, and other parts of South America in the form of rounded or flattened grains mixed with sand and other alluvial depositions. In 1826 it was discovered in a sienitic rock in South America, associated with gold. Rich mines of gold and platinum have also been recently discovered in the Uralian Mountains.

What are some of the properties of platinum?

It is the heaviest of all known substances. Its color is between those of steel and silver, it is malleable, ductile and easily welded. Leaves of platinum are used for wrapping substances that are to be exposed to great heat and for this reason it is rendered an invaluable metal to the chemist.

What is said of its hardness?

It is extremely hard but receives a high polish, and has been used in the small way for reflectors, and for instruments requiring hardness and permanency.

Is platinum of as great value as gold?

The value of platinum is intermediate be-

tween that of gold and silver, and in Russia it has been coined into money.

How is pure platinum obtained ?

Pure platinum is generally obtained from spongy platinum, which is heated to whiteness and then quickly compressed by strong pressure, it can then again be heated, hammered out into uniform pieces, rolled into plate, drawn into wire, &c.

Does it undergo any change from the atmosphere ?

Platinum undergoes no change from the combined agency of air and moisture ; it may be exposed to the strongest heat of a smith's forge, without suffering either oxydation or fusion.

What are some of the uses of platinum ?

It is employed in the manufacture of many indispensable articles for the laboratory of the chemist and in the arts.

How is its affinity for lead shown ?

If a piece of lead foil, and another of platinum foil of equal dimensions be rolled up together, and the flame of a candle be cautiously directed by a blow-pipe towards the edges of the rolls, at about a red heat, the two metals will combine with a sort of explosive force, scattering their melted particles, and emitting light and heat in a surprising manner.

When and by whom was palladium discovered?

This metal was discovered by Dr. Wollaston in 1803, in an ore of platinum. It derived its name from the planet pallas.

What are some of its properties?

It resembles platinum in its color and lustre, is malleable, ductile and harder than wrought iron; its point of fusion is intermediate between gold and platinum and is dissipated in sparks when intensely heated by the compound blow-pipe.

#### RHODIUM.

By whom was rhodium discovered?

This metal was discovered about the same time as palladium, by Dr. Wollaston.

How is it procured?

It has been procured in very small quantities from the solution of crude platinum, in the form of black powder, which requires the strongest heat of a wind furnace for its fusion, and when fused has a white hard color and metallic lustre.

What are some of its properties?

It is hard and extremely brittle, and its specific gravity is about 11, in its pure state it is not attacked by any of the acids, but when alloyed with other metals, is oxydized and dissolved by the nitro-muriatic acid.



By whom was osmium discovered ?

This metal was discovered by Mr. Tennant, in 1803, in the black powder left after the digestion of crude potassium in nitro-muriatic acid.

How can it be obtained ?

It can only be obtained as a metal in a dis-integrated state, it is capable of supporting a white heat without being volatilized or fused, it is of a dark grey or blue color.

What does osmium heated with chlorine form ?

A chloride of a beautiful color.

#### IRIDIUM.

By whom was iridium discovered ?

This metal was discovered by Mr. Tennant, in 1803, and about the same time by Descotils of France.

What are some of its properties ?

It is the most infusible metal known, having only been fused by the large galvanic battery of Mr. Children ; when it appeared as a globule of a brilliant white color, and metallic lustre ; is attacked with great difficulty by nitro-muriatic acid, but is oxydized when heated with nitre.

Is this metal capable of forming oxides ?

Berzelius has lately ascertained that this metal is capable of forming four oxides and four chlorides.

## LECTURE XIII.

### SALTS.

How are the salts formed ?

Every acid usually forms a salt with every metallic base, hence there is an infinite number of salts.

How are they divided ?

They have been divided by some chemists into four orders. Oxy-salts, hydro-salts, sulphur salts, and haloid salt.

What does the first order contain ?

The Oxy-salts, or those of which the acid or base contains hydrogen.

What does order 2d contain ?

The Hydro-salts, or those of which the electro-positive or negative ingredient is a sulphuret.

What does order 3d contain ?

The sulphur salts, or those which the electro-positive or negative ingredient is a sulphuret.

What does order 4th contain ?

The Haloid-salts, or those of which the electro-positive or negative ingredient is a haloidal.

Are the salts capable of crystallizing ?

Most of them are solid at common temperatures, but are also capable of being crystallized.

Are the colors of all the salts the same?

They vary greatly, having no necessary connection with the color of their elements.

Are the salts odorous?

Very few of them possess any odor.

Do salts differ in their affinity for water.

Salts differ greatly in their affinity for water, and also in their solubility, for some dissolve in less than their weight in water, while others require several times their weight.

On what does this difference depend?

Their affinity for water, and on their cohesion?

When may a salt be considered dry?

When it contains more than half its weight in water.

When a salt of this kind becomes exposed to heat what becomes of it?

It dissolves.

Does atmospheric pressure have an influence on the crystallization of salts.

It is said to have a great influence.

Give an example.

Take a concentrated solution of sulphate of soda, and make it boil briskly; then cork the flask tightly; the upper part will be full of vapor, and the solution will cool down to the temperature of the air without crystallizing,

and it may be preserved in that state for months without change.

When do salts, lose their water of crystallization?

Salts, when exposed to the air, lose their water of crystallization, and crumble down into a fine powder.

What is this termed?

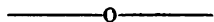
This is commonly denominated effervescence.

When do salts deliquesce?

When they absorb water from the atmosphere, they are said to deliquesce.

What is the phenomena called when salts inclose mechanically within their texture particles of water, by the expansion of which, when heated, burst with a crackling noise?

Decrèpilation is the name applied to this phenomena.



## LECTURE XIV.

### *Oraer 1.—Oxy-salts.*

What does this order contain?

This order of salts includes no compound, the acid or base of which does not contain oxygen.

How are double salts formed ?

They are composed of two acids and one base, of two bases and one acid, or of two different acids and two different bases.

#### SULPHATES.

Do any of the sulphates occur native ?

Several sulphates exists in nature, but the most abundant are sulphates of lime and baryta.

How may they be formed ?

By the action of sulphuric acid on the metals, their oxides, carbonates, or by double decomposition.

Does the solubility of the sulphates vary ?

They do.

How many may be regarded as insoluble.

Six of the sulphates are really insoluble.

What are their names ?

The sulphates of baryta, the oxides of tin, antimony, bismuth, lead and mercury.

How may an insoluble sulphate be detected ?

The sulphate of baryta, or strontia may be detected by mixing it in fine powder with three times its weight of carbonate of potassa or soda, and exposing the mixture in a platinum crucible for half an hour to a red heat.

By what name was sulphate of potassa formerly called ?

Sal de duobus.

What are its properties ?

It is white, and tastes saline and bitter, crystallizes in short six-sided prisms bounded by six-sided pyramids.

Is it ever found native ?

It is, though not abundantly, it also forms a constituent of the well-known alum.

Can this salt be prepared artificially ?

It can be by saturating carbonate potassa with sulphuric acid ; and it is procured abundantly as a product of the operation for preparing nitric acid.

How is bisulphate of potassa formed ?

By exposing the neutral sulphate, with half its weight of strong sulphuric acid, to a heat just below redness, in a platina crucible, until acid fumes cease to escape.

What are some of its properties ?

It has a sour taste, reddens litmus paper, and is used for cleaning coin.

By what name is the sulphate of soda known ?

The sulphate of soda is commonly known by the name of glauber salts.

Where is it found ?

It is frequently found on the surface of the earth, and in mineral springs.

What are some of its properties ?

It tastes bitter, cooling and saline, it crystallizes in four and six-sided prismatic crystals, but its primary form is an octahedron; effloresces on exposure to the air, and undergoes watery fusion when heated.

What are some of the uses of sulphate of soda?

It is used in pharmacy, in the manufacture of glass, and it is sometimes decomposed for the purpose of obtaining soda by igniting it with chalk and charcoal, or with iron and charcoal.

By what name is the sulphate of baryta known?

It is frequently called heavy spar.

Is it ever found native?

It is found abundantly, as an associate of other minerals in veins, and is a common and abundant native product, and from it, or the carbonate of baryta, all the artificial compounds of barium are formed.

Where is it found?

In the mines of Cumberland, Westmoreland, Transylvania, Hungary, Saxony and Hanover.

Is it ever found in the United States?

It is, in Missouri and Illinois.

Is it insoluble?

It is one of the most insoluble salts.

By whom has it been used?

Painters use it as a substitute for white lead.

What are the properties of the sulphate of strontia ?

It has a blue tint, and is called celestine ; it is nearly insoluble, requiring 4000 parts of cold, 3840 of hot water to dissolve it.

Is it ever found in a native state ?

It is, in the form of beautiful crystals, in Sicily, and also on Strontia Island in lake Erie.

Is the sulphate of lime a natural production ?

This salt occurs abundantly in nature. The mineral called anhydrite, is an anhydrous sulphate of lime ; and all the varieties of gypsum are composed of the same salt, united with water.

What have the pure crystallized specimens of gypsum been called ?

Selenites.

What are some of its properties ?

It is nearly tasteless, soluble in 500 parts of cold, and 450 of boiling water ; it is generally found in spring and river waters, and especially in those called hard.

For what is it used ?

This salt, under the name of plaster of Paris, is largely used in agriculture ; it is used for casts, busts, and a great variety of purposes in the arts.

By what name is the sulphate of magnesia generally known ?



Epsom salts, and it is frequently contained in mineral springs as at Epsom in England. It is one of the most common purgatives, and is much employed in medicine.

Is it ever found native?

It is found incrusting the damp walls of cellars and new buildings.

What are some of its properties?

Its taste is saline, bitter, and nauseous; its crystals are small, quadrangular prisms, slightly efflorescent in dry air.

How can it be distinguished from the sulphate of soda?

By the form of its crystals.

Sulphates of iron are commonly denominated what?

Sulphate of the protoxide of iron is known by the name of green vitriol, or copperas.

What are some of its uses?

It is of great use in dyeing.

Sulphate of zinc is known by what name?

Sulphate of zinc is the white vitriol of commerce.

What are some of its properties?

It is of a white color, tastes bitter, and crystallizes by spontaneous evaporation; the crystals dissolve in two parts and a half of cold, and are still more soluble in boiling water.

Is it ever found native?

This salt is found native in places where the sulphuret of zinc occurs.

Is it ever prepared artificially?

It is by the action of sulphuric acid upon metallic zinc, during the process for preparing hydrogen gas.

What are some of its uses?

It is used in medicine and the arts.

Sulphate of copper is generally denominated what?

Blue vitriol, and common vitriol.

What are some of its properties?

It slightly effloresces on exposure to the air, its crystals are of a light color, the primary form of which is the rhomboidal prism.

#### DOUBLE SULPHATES.

What is the sulphate of soda and lime?

The glauberite of mineralogists.

By what name is the sulphate of potassa and alumina known?

Alum.

What are some of its properties?

Alum has a sweetish astringent taste, and reddens litmus paper; it crystallizes readily in octahedrons, or in segments.

What are some of its uses?

Alum is of great use in medicine and in the arts, especially in dying and calico printing.

What does iron alum resemble?

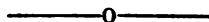
Common alum, with this exception, that it frequently has a pink tint.

What is said of the chrystals of chromium alum?

They are black by reflected, but red by transmitted light.

How is manganese iron formed?

By the unpleasant alluvia in common alum, by the sesquioxide of manganese.



## LECTURE XV.

### NITRATES.

How may nitrates be prepared?

By the action of nitric acid on metals, on the sallifiable bases, or on carbonates. As nitric acid forms soluble salts with all alkaline bases, the acids of the nitrates cannot be precipitated by any reagent—T.

How are the nitrates decomposed?

By the agency of heat.

What is the process of oxydation by nitre called ?

Deflagration.

What is nitrate of potassa commonly called ?

It is a colorless salt, and is generally known by the name of nitre or salt-petre.

Is it ever found native ?

This salt is generated spontaneously in the soil ; it crystallizes readily in six-sided prisms.

In what is nitre frequently employed ?

Nitre is sometimes employed as an oxidizing agent in the formation of nitric acid.

What are some of its uses ?

In the East Indies it is employed for cooling mixtures ; in the arts it is used extensively in making gunpowder, and it is also used in agriculture as a manure.

Of what is gunpowder a compound ?

It is a solid explosive mixture, composed of nitre, sulphur, and charcoal, reduced to powder and mixed intimately with each other.

Are there any other uses to which nitre is applied ?

It is used very much in the preservation of meat.

Has nitre ever been mistaken for sulphate of soda ?

It has, and has thus been the source of fa-

tal accidents.

How may it be distinguished from the sulphate of soda?

By its deflagrating when thrown upon burning coals.

Does nitre ever detonate?

It does not except when in contact with inflammable matter.

What has Nitrate of Soda been called by old writers?

Cubic nitre.

Where is it found?

It occurs in the soils of India, and in Peru.

What are some of its properties?

It crystallizes in rhombs, and is somewhat deliquescent.

What are some of its uses?

It is used in the preparation of fire-works.

For what is Nitrate of Baryta used?

This salt is sometimes used as a reagent and for preparing pure baryta.

What are some of its properties?

It crystallizes in transparent octahedrons, and is very apt to decrepitate by heat, unless previously reduced to powder.

How is Nitrate of Ammonia formed?

By neutralizing dilute nitric acid, by carbonate of ammonia and evaporating the solution.

How is the Nitrate of Strontia formed?

It is prepared from the carbonate of strontia.

What are some of its properties ?

It crystallizes in anhydrous octahedrons, which undergo no change in a moderately dry atmosphere, and are insoluble in alcohol.

For what is it used ?

The red fire employed at theatres.

Where is the Nitrate of Lime found ?

This salt is often generated in old plaster and mortar, and is found native in great abundance in caverns in Kentucky.

What are some of its properties ?

It is very bitter and deliquescent, and is difficult to procure in regular crystals.

Is the Nitrate of Ammonia ever found native.

It is frequently found native.

What are some of its properties ?

It is very bitter.

How is the Nitrate of Protoxide of Copper formed ?

By the action of nitric acid on copper.

What are some of its properties ?

It crystallizes in prisms of a deep blue color, and when heated to redness, it yields pure oxide of copper.

How is the Nitrate of Protoxide of Lead formed ?

By digesting litharge in dilute nitric acid.

What are some of its properties?

It crystallizes in octahedrons, and has an acid reaction.

For what is the Nitrate of Silver used?

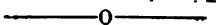
It is the principal ingredient in indellible ink.

What are some of its properties?

It is colorless and transparent, is often adulterated with nitre, which is melted in it.

Can you give an experiment with nitrate of silver?

Place a small piece of lunar caustic upon charcoal, and heat it before the blow-pipe; it deflagrates, and yields metallic silver, which may be easily fused at a stronger heat.



## LECTURE XVI.

### CHLORATES.

What is said of the chlorates?

The salts of chloric acid are very analogous to the nitrates.

Are any of the chlorates found native?

None of them are found native?

How can the Chlorate of Potassa be formed?

By transmitting chlorine gas through a concentrated solution of pure potassa, until the alkali is completely neutrallized.

Can you give an experiment with the chlorate of potassa?

Chlorate of potassa when thrown on glowing coals, deflagrates more briskly than nitre, and the oxygen as it is liberated, occasions a very energetic combustion of the coal.

Is this salt ever employed in the preparation of gunpowder?

It is not, the rapidity with which it explodes would be too much for the guns, yet on this account it is very serviceable in fire-works for producing variegated fires.

Does it explode easily?

It does, it may explode by merely rubbing or pounding it.

What then are some of its uses?

This salt has been much used in the manufacture of lucifer matches, and in the preparation of percussion powder.

How is the Chloride of Baryta prepared?

By digesting for a few minutes a concentrated



solution of chlorate of potassa, with a slight excess of silicated hydrofluoric acid, the alkali is precipitated in the form of an insoluble double hydrofluorate of silica and potassa, while carbonic acid remains in the solution. The liquid after filtration, is neutralized by carbonate of baryta, which throws down the excess of silicated hydrofluoric acid, and chloride of baryta remains in solution. *Gray.*

How are the hypochlorites produced?

By the action of chlorine gas on the salifiable bases.

Which is the most important of them?

The hypochlorite of lime.

What are some of its uses?

It is used principally for commercial purposes.

#### PHOSPHATES.

How many acids are isomeric?

There are three acids of phosphorus which are isomeric; the phosphoric, the pyrophosphoric, and metaphosphoric.

What does arsenic acid resemble?

Phosphoric acid in many of its properties.

Name some of the arsenites?

The arsenites of potassa, soda, and ammonia, may be prepared by acting with those alkalis on arsenous acid.

Are they soluble in water ?

They are.

For what is arsenious acid used ?

Arsenious acid prevents the decay of organic substances, therefore the skins of animals intended for shipping are rubbed with arsenic upon the flesh side, glass makers add to it melted glass, to convert its black or green color into yellow, it is also used by hat makers to remove the shining smooth coating from the fur of hares.

## CHROMATES.

How may the chromates be distinguished ?

They may generally be known by their yellow or red color.

Can they be decomposed by heat ?

They can.

How is the chromate of potassa formed ?

It can be prepared by heating to redness chromate of iron, with nitrate of potassa.

What are some of its properties ?

It has a cool, bitter and disagreeable taste.

For what is the bichromate of potassa used ?

It is of great use in the art of dyeing.

What are some of its properties ?

When slowly formed, it is deposited in crystals of a rich red color.

What does the precipitate form ?

Chrome Yellow, which is well known as the richest and most vivid of all the yellow pigments, and by mixing it with white substances, for instance, talc chalk, clay, gypsum, &c. and numerous other shades of yellow are obtained by mixing it with Prussian blue, the green pigments are obtained as, olive green, Naples green, green cinnabar, &c.

Which is one of the most important of the chromates?

Chromate of iron, it is a black mineral, mostly obtained in North America, and is manufactured into a red salt which consists of potassa and chromic acid, and the other compounds of chromine are prepared from this salt.

How is the chromate of lead formed?

By adding chromate of potassa in solution to a solution of nitrate or acetate of lead, as long as there is any precipitate.

How is chrome orange formed?

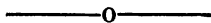
Chrome yellow stirred up with water and heated with carbonate of potassa forms chrome orange, which is also used by painters. The chrome yellow passes into orange and red by abstracting yellow chrome acid, while yellow chromate of potassa becomes red by adding more chrome acid.

Is chrome yellow much used in the arts?

Chrome yellow has obtained a very important application in the dyeing and printing of yarns and fabrics,

Give an example?

First dip a piece of cotton into a solution of chromate of potassa, then after it has become dry, into a solution of lead, and it is dyed yellow.



## LECTURE XVII.

### BORATES.

How are the borates distinguished ?

By digesting any borate in a slight excess of strong sulphuric acid, evaporating to dryness, and boiling the residue in strong alcohol, a solution is formed which has the property of burning with a green flame.

What are some of the uses of borax ?

It is used in forming colors. A very beautiful violet is made from a flux composed of borax and flint glass, colored with one-sixth part of the purple of cassins, precipitated from muriate of gold, by protomuriate of tin.

Can any other colors be formed ?

A fine red is made from red oxide of iron, prepared by nitric acid and heat, mixed with a flux of borax and a small proportion of red lead.

## CARBONATES. .

How are the carbonates distinguished from the salts ?

By being decomposed with effervescence, owing to the escape of carbonic acid, by nearly all the acids, and nearly all of them may be deprived of their acid by heat.

Are any of the carbonates found native ?

Several of the carbonates occur thus, such as the carbonate of soda, baryta, strontia, lime and magnesia.

How is the carbonate of potassa formed ?

This salt is procured in an impure form, and is the potash and pearlash of commerce.

How is the potash of commerce procured ?

From the ashes of land plants by <sup>to make life</sup> lixiviating them, and then evaporating the solution to dryness.

What are some of its uses ?

It is used in the manufacture of soap and glass.

Where is it manufactured ?

In the United States, Canada, and most parts of Europe.

How is pearlash formed?

The potash calcinated at a moderate heat, burns off the coloring particles, and the salt becomes of a spongy texture and of a beautiful bluish white tinge.

How is the bicarbonate of potassa made?

By transmitting a current of carbonic acid gas through a solution of the carbonate of potassa.

What are some of its properties?

It crystallizes in eight-sided prisms, and is milder than the carbonate.

By whom is it used?

It is principally used by bakers

How is the Carbonate of Soda obtained?

By lixiviating the ashes of sea weeds, in the same manner as the carbonate of potassa is obtained from the ashes of land plants.

For what is it used?

It is employed in washing and bleaching, in the manufacture of glass and soap, and it is now manufactured on a large scale in chemical works.

By what name is it sometimes called?

It is frequently denominated sal soda, and another variety is called kelp.

How is carbonate of ammonia obtained?

The only method of obtaining carbonate of ammonia, is by mixing dry carbonic acid with ammoniacal gas.

Where is the carbonate of baryta found ?

It occurs native in the mineral witherite.

From whence does the mineral derive its name ?

Dr. Withering, by whom it was discovered.

Is the carbonate of strontia ever found native ?

It is, at Strontium, in Argyleshire.

By what name is it known ?

Strontianite.

Is the Carbonate of Lime ever found native ?

It is a natural production, and is found under a great variety of forms, such as limestone, marble, chalk, Iceland spar, &c.

Is Carbonate of Magnesia found native ?

It is the mineral called magnesite.

What are some of its properties ?

Its color is white, and dissolves very slowly in acid, unless it be reduced to powder.

Is the carbonate of protoxide of iron found in nature ?

It is very abundant occurring sometimes in masses, and sometimes in crystals of a hexagonal form.

What is the carbonate of protoxide of lead called ?

White lead of painters.

## LECTURE XVIII.

### *Order 2.—Hydro-salts.*

What does the hydro order include ?

Those salts the acid or base of which contain hydrogen.

What salts are included in this order ?

Those which are formed by the hydracids with ammonia and phosphuretted hydrogen.

By what name is the hydrochlorate of ammonia called ? *hydrochloric*

The sal ammoniac of commerce, and it was formerly brought from Egypt.

From what does it derive its name ? It is said to receive the name, sal ammoniac, from being first obtained from the vicinity of the temple of Jupiter Ammon.

What are some of its properties ?

This salt has a saline taste, is insoluble in water and alcohol.

What are some of the uses of hydrochlorate of ammonia ?

It is used extensively in the arts, for a variety of purposes, it is also used in medicine.

### *Order 3.—Sulphur-salts.*

What are sulphur salts ?



They are double sulphurets, just as the oxy-salts are double oxides.

How are the sulphur salts constituted?

The sulphur salts, with two metals, are so constituted, that if the sulphur in each were replaced by an equivalent quantity of oxygen, it would form an oxy-salt.

Into what are the sulphur salts divided?

Families which contain the same sulphur acid.

How is the generic name formed?

The generic name of each family is formed from the sulphur acid, terminated with sulphuret.

Is the class of sulphurs extensive?

They are and include several families of hydro-sulphurets, carbo-sulphurets. &c.

#### *Order 4.—Haloid-salts.*

Does the order of haloid salts include many families?

It does.

To what do the haloid acids belong?

They generally belong to the electro-negative metals.

To what do the haloid bases belong?

To the electro-positive metals.

## PART V.

# ORGANIC CHEMISTRY.

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## LECTURE I.

Of what does organic chemistry treat?

Of those compounds, which are of vegetable or animal origin.

Of what does inorganic chemistry treat?

Inorganic chemistry comprehends all matter destitute of a living principle, such as fluids, gases, minerals.

In what does organic differ from inorganic substances?

In being composed of the same elementary principles, hydrogen, carbon and nitrogen. *say*

What is the first natural division of organic bodies?

Into animal and vegetable.

Is it difficult to determine wherein the difference consists?

Many philosophers have attempted it, but have failed. Some writers, among whom was the celebrated Buffon, have believed that there is in fact no exact boundary between the animal and vegetable kingdoms.

Can organic substances be formed artificially?

They cannot be formed by the direct union of their elements.

How can they be obtained?

Only as existing in organic bodies.

What belongs to all organic bodies?

A living or vital principle.

Are they the subject of decay while the living principle is retained?

They are not, for during life the elements of organic bodies are held together by vital affinity; for it is life which gives the body the power of resisting the operations of decay.

Do we know anything of this vital principle?

It has eluded the researches of man, and its operations are conducted in such a mysterious manner, that it is not probable that the vague speculations of the inquiring mind on this point, will ever lead to clear ideas here below. We feel indeed the rushing of the vital current in the joy which penetrates us in spring, and the melancholy which seizes us in autumn, but whence this force comes, and whither it goes, and how it calls forth, as it were by magic, the wonders of the vegetable world we are absolutely ignorant.

What is the difference between a stone and a plant?

If you remove a stone from one place to an-

other, it suffers no alteration ; if you take up a plant it withers and dies.

Are any of the organic bodies acid ?

Many of them are distinctly acid, not only to the taste, but possess other properties of acids and they are found among vegetable and animal products.

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## LECTURE II.

### CHEMICAL PHENOMENON OF VEGETATION.

What is germination ?

It is the process by which a new plant originates from the seed.

Of what does a seed consist ?

A seed consists essentially of two parts, the germ which is endowed with the vital principle, and the cotyledon or seed lobes, which furnish nourishment to the plant before it can derive it from the earth.

Of how many parts is the germ composed ?

Two, the radicle, which shoots downward, and which is usually the first to break through the coats of the seed, and the plumule, which rises into the air and forms the stem of the plant.

How many conditions are necessary to germination ?

Three, viz. moisture, a certain temperature, and oxygen gas. Dry seeds will not germinate; or, if moist, germination will not take place at  $32^{\circ}$ , nor at the temperature of boiling water, which deprives the germ of its vitality.

Is air necessary to germination?

It is, and under an exhausted receiver, a seed will not germinate, although possessing every other requisite. If seeds are buried deeply in the earth, they will not vegetate, unless accidentally ploughed up or exposed to the contact of the atmosphere. Air furnishes that important agent, oxygen, which is the first moving principle of vitality.

#### GROWTH OF PLANTS.

Are there any points of resemblance between the growth of plants and animals?

There are many points of resemblance.

What are the chemical changes called which the sap undergoes?

The respiration of plants, and is probably very analogous to what takes place in the blood of animals.

Where are the various chemical changes seen, that take place in the germination of seeds?

In the process of malting. A kind of saccharine fermentation is produced, by which

nutriment is supplied for the young plant during the early stages of its growth

What constitutes the difference between the respiration of plants and animals?

Animals, during respiration, are constantly giving off carbonic acid, while plants, by the action of light, absorb carbonic acid, and give off oxygen.

#### FOOD OF PLANTS.

From what do plants derive their food?

Mostly from the earth, the roots particularly; the leaves and stem receive nourishment from the air. There are some plants, however, which do not derive their nutrition from this source, as they are found to vegetate in distilled water, and to grow for sometime when merely suspended in the air.

How is this accounted for?

On the supposition that carbonic acid is the proper food for plants.

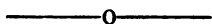
Where is carbon obtained?

From the atmosphere, it is absorbed by the leaves of the plant, and appropriated to its nourishment.

How is the nitrogen of plants obtained?

It is probably obtained from the atmosphere, which always contains a quantity of ammonia, derived from the putrefaction of organic matter. some plants derive nitrogen from the

atmosphere much faster than others. Wheat, though it contains much nitrogen, is scarcely capable of absorbing it from the air, but derives it from the organic matter of the soil.



### LECTURE III.

#### VEGETABLE CHEMISTRY.

what are vegetable substances composed?

Of the three elementary principles, oxygen, hydrogen and carbon.

What do vegetable substances produce?

Chemical combinations, and are distinguished by the name of proximate, or ultimate principles?

What are proximate principles?

Such as are obtained from the plants, such as sugar, starch and gum.

What are ultimate principles?

Such as are obtained by the destruction of the compounds.

What constitutes proximate analysis?

The process by which vegetables are separated.

What constitutes ultimate analysis?

It consists in the reduction of proximate principles into their elements.

How was this formerly done ?

By a process denominated destructive distillation.

In what does it consist ?

When the ultimate analysis is made by heating to redness in close vessels, the process is denominated destructive distillation.

#### VEGETABLE ACIDS.

What are vegetable acids ?

That class of bodies which are procured from vegetable substances, such as the juices of sour fruit, sour wine, or vinegar.

Are vegetable acids decomposed by red heat.

They are.

Are they the products of nature alone ?

Some of them are, and others are the products of both nature and art.

By whom was oxalic acid discovered ?

Scheele.

Where is it found ?

In several species of sorrel, and belongs to the genus *oxalis* and *rumex*, and it also occurs in combination with lime or potassa.

Can oxalic acid be made artificially ?



It can, by the action of nitric acid upon various vegetable and animal substances.

What are some of the properties of oxalic acid?

It crystalizes in slender, flattened four and six-sided prisms, with two sided summits, the primary form of which is an oblique rhombic prism. It has a very sour taste, reddens litmus paper, and forms neutral salts with alkalies.

Is oxalic acid poisonous?

It is a very rapid and fatal poison, and accidents have occurred frequently in consequence of its resemblance to Epsom salts.

How may these substances be distinguished?

By the taste, or by its reddening litmus paper.

When oxalic acid has been swallowed accidentally, what is the best remedy?

Take copious draughts of lime, chalk or magnesia water, and vomiting should be excited as soon as possible.

How is it distinguished from all other acids?

By the form of its crystals, and by its forming with lime water an insoluble precipitate.

For what is oxalic acid employed as a test?

Lime and oxalates of potassa.

Oxalic acid with potassa, forms how many compounds?

Three.

In what is the binoxalate found?

In the sorrel, a plant.

What are some of its uses?

The binoxalate is often sold under the name of essential salt of lemons for removing iron mould, stains of ink, &c.

Which is the least soluble of these salts?

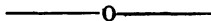
The quadroxalate, which is obtained by digesting the binoxalate in nitric or muriatic acid.

How is the oxalate of ammonia prepared?

By way of decomposition.

What are some of the properties of this salt?

The oxalate of ammonia is soluble in pure water, and may be exposed to a high temperature without decomposition.



## LECTURE IV.

### ACETIC ACID.

How is acetic acid produced?

By fermentation from wine, cider and other liquids.

By what other name is it known?

Acetic acid is known by the name of pure vinegar.

Where is it found?

Acetic acid is found in a pure state in the campeachy wood and the sap of the elm, and is generated in large quantities in the destructive distillation of vegetable substances.

How may it be obtained?

By the distillation of common vinegar, which is prepared by exposing malt or vinous liquor to the free access of atmospheric air at a temperature slightly elevated.

What are some of its properties?

It is transparent, colorless and very volatile; it has a very sour taste, and an agreeable, refreshing odor.

How is the acetic acid for chemical purposes generally prepared?

By the distillation of wood, and it is most commonly known by the name of pyroligneous acid.

By what name is the acetate of lead known?

The sugar of lead.

How is it prepared?

By dissolving either the carbonate or litharge in distilled vinegar.

Is it poisonous?

It is when taken internally.

What are some of the uses of sugar lead?

It is used in the arts, in medical and surgical practice as a sedative, and in the laboratory as a reagent.

Which of the acetates of copper is the best known?

There are three or four different kinds of acetates, but the best known, is the verdigris used by painters.

How is it prepared?

In the south of France it is prepared in large quantities, by covering copper with the refuse of the grape, after the juice has been extracted.

How is the purer article obtained?

By covering copper plate with cloth soaked in pyrolignous acid.

For what is the acetate of alumina employed?

As a mordant of fixing colors.

By whom has the acetate of ammonia been used?

Physicians.

From what does malic acid derive its name?

It is so called because it is obtained from the apple, malum; it is also found in grapes, currants, gooseberries, oranges, and in most acidulous fruits.

By whom was it discovered?

Scheele, in the year 1785.

What are some of its properties ?

It is white, inodorous, and crystallizes with difficulty.

By whom was citric acid discovered ?

Scheele, and it is found in large quantities in the juice of the lime and lemon.

What are some of its properties ?

It crystallizes in large and transparent rhomboidal prisms, which are terminated by four plane surfaces, and undergo no change in air. It has a sour taste, with an agreeable flavor when diluted, reddens litmus paper, and neutralizes alkalies.

What are some of its uses ?

It is used in calico printing, and for medicinal and domestic purposes instead of lemon juice,

## LECTURE V.

### TARTARIC ACID.

By whom was tartaric acid discovered?

Scheele, in the year 1770.

Where is it found?

It exists in combination with lime and potassa, in the juice of acidulous fruits.

From what is the tartaric acid of commerce obtained?

The juice of the grape.

What are some of its properties?

It has a sour taste, and is very agreeable when diluted with water, it reddens litmus paper equally, and is soluble in five or six times its weight in water.

How is it distinguished from other acids?

By forming a white precipitate, acid tartrate of potassa, when mixed with any of the salts of that alkali.

What are some of its uses?

It is of great use to calico printers, who thicken it with gum or roasted starch and apply it to those parts of a piece of calico previously dyed red or blue, as are to be rendered colorless by means of chloride of lime.

Bitartate of potassa, in an impure form, is known by what name ?

Crude tartar, and is found deposited on the sides and bottoms of wine casks.

Is this the same form from which the tartar of commerce is obtained ?

It is, and which, by being purified is known by the name of cream of tartar.

What is cream of tartar ?

Tartaric acid, combined with potash, forms what is commonly called cream of tartar.

What are some of its uses ?

It is used for the preparation of tartaric acid, and as a medicine.

Under what name is the compound of tartrate of antimony and potassa sold ?

Tartar emetic.

How is it prepared ?

By boiling protoxide of antimony with cream of tartar.

How are its effects neutralized ?

By vegetable astringents, as tea, or peruvian bark, which may therefore be used as an antidote in case of taking too powerful a dose.

What are some of its uses ?

It is used in medicine as an emetic ; but taken in larger doses it is highly piosonous.

By what name has tartrate of potassa and

soda been called ?

Rochelle salt.

#### TANNIC ACID.

Where is tannic acid found ?

It exists in an impure state, in gall nuts, in the bark of most trees, in the leaves of the tea plant, sumach and whortle berry, and in astringent plants generally.

What are some of its properties ?

It is colorless, inodorous, and has purely an astringent taste. It is soluble in water and reddens litmus.

With what does tannic acid combine ?

The skins of animals, forming an insoluble compound which does not putrefy.

Of what is this the basis ?

Most kinds of leather.

In what does the art of tanning consist ?

In promoting the union of these substances.

By whom was gallic acid discovered ?

Scheele, in the year 1786.

Where is it found ?

Gallic acid is found, ready formed in the bark of many trees, and in gall nuts.

What are some of its properties ?

Gallic acid, when pure, is in the form of white crystals, has a sour taste, reddens lit-



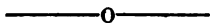
mus, and is highly astringent. With a salt of iron, it forms a dark blue colored compound, which is the basis of ink.

Where is this metallic acid found ?

In a rare substance called honey stone, occasionally met with in Thuringra in Germany.

What are some of its properties ?

It crystallizes in hard prisms, or in fine needles, forming sometimes by their reunion a globular mass.



## LECTURE VI.

### CROCONIC ACID.

What is croconic acid ?

It is a yellow crystallized solid, soluble in water, and in alcohol. Its salts are yellow.

By whom was lactic acid discovered ?

Scheele, in 1780, and it was so named from being first noticed in sour milk.

What are some of its properties ?

It is colorless, without smell, but very sour and its salts are termed lactates.

How is succinic acid obtained ?

By distillation from amber.

How is it rendered from a yellow to a pure white ?

By being dissolved in nitric acid.

What are some of its properties ?

Its taste is rather bitter, reddens litmus paper, and combines with alkaline bases.

Where is benzoic acid found ?

In gum benzion, in the *Laurus benzion*, and in the vanilla.

What are some of its properties ?

It has a sweetish and aromatic rather than a sour taste, reddens litmus paper, and unites with bases.

How may the sublimation of benzoic acid be shown ?

Suspend a small branch of a rose bush in a tall glass, without a bottom, place a small quantity of the acid upon a plate of metal, and over this, the jar ; at the same time apply the heat of a lamp to evaporate the acid, and the branch will be covered with delicate crystals.

How is the camphoric acid obtained ?

From camphor, by distillation with nitric acid.

What are some of its properties ?

It has a somewhat bitter and sour taste, an aromatic odor, reddens litmus, and is sparingly soluble in cold water.

Where is Prussic acid obtained ?

From peach meats and blossoms, bitter almonds, &c,

What are some of its properties?

It is a limpid colorless liquid, and gives out a strong odor, similar to that of peach blossoms.

Is prussic acid ever poisonous?

It is a powerful poison producing insensibility and convulsion, which are soon followed by death. A single drop placed upon the tongue of a dog, causes death in a few seconds.

How are the effects of prussic acid counteracted?

By the solution of ammonia.

What are some of its uses?

In a very dilute state, it is used in medicine.

When is cinamic acid formed?

When oil of cinnamon is long exposed to the action of the atmosphere.

Where is Meconic acid found?

In opium, combined with morphine.

What are some of its properties?

It is very sour, reddens litmus, and is soluble in water and alcohol.

How is Stearic acid formed?

It is obtained from soap, is tasteless, insoluble in water, and burns like wax.

From what is Oleic acid obtained?

It is formed from the soap made from linseed oil and potassa, it has little taste, and burns like the fixed oils.

From what is Margaric acid obtained?

The various oils and fats.

How is Ulmic acid formed?

By the long exposure of wood to the action of air and moisture.

How is antimonic acid formed?

By mixing powdered antimony with water, and throwing the mixture into a glowing hot crucible,

Can you give an experiment with chromic acid?

Mix in a small mortar as much chromic acid as can be taken up on the point of a knife with about one-quarter as much of powdered camphor, and then let some drops of alcohol fall from a considerable height into the mortar, instantaneous ignition and deflagration ensue, almost as if you were burning gunpowder. The residue in the mortar after decomposition presents the appearance of an elegant green mossy vegetation.

Are there any other vegetable acids?

There are many others, but we have noticed some of the most important.

## LECTURE VII.

### VEGETABLE ALKALIES.

What do vegetable alkalies comprehend ?

Those proximate principles which exist naturally in plants, and possess alkaline properties.

When was the existence of the vegetable alkalies discovered ?

In 1805, but they excited no attention until about 1816.

How are they distinguished from most vegetable substances ?

By their containing nitrogen.

Are these substances ever found in a free state in plants ?

They are not, but appear to be combined with an acid, with which they form salts, more or less soluble in water.

For what is the vegetable alkali termed morphia, used ?

Morphia is the native principle of opium, in which it is combined with various other principles.

What are some of its properties ?

It readily crystallizes from its alcoholic solu-

tion in small right rhombic prisms.

How are the salts of morphia prepared?

By dissolving them in dilute acids, and evaporating the solution.

Are the salts of morphia poisonous?

They are a very powerful poison, one-half a grain in solution will produce an alarming effect on the animal system.

Are they ever used in medicine?

Some of them are useful as medicine, of which, the hydrochlorate and acetate are the principal.

By whom was calchonia and quinia found?

They were detected by Pélletier and Caver-ton in 1820. Cinchonia exists in the Cinchona condaminca, or pale bark; and quinia often with a little cinchonia is present in *C. cordifolia*, or yellow bark; and they are both contained in *C. oblongifolia*, or red bark.

What are some of the properties of Cinchonia?

It is insoluble in cold water, and nearly so in hot water and in boiling alcohol it is freely dissolved.

What does Quinia form?

Several salts, one of which, the sulphate, is manufactured in large quantities for medical purposes.

By what name is it commonly known.

Quinine, and its use as a specific in intermit-

ting fever is well known.

What are some of its properties ?

It crystallizes in delicate white needles, having the appearance of amianthus, has a bitter taste, and is less soluble in water than sulphate of cinchonia.

Is it ever adulterated ?

The sulphate of quinia from its commercial value, is frequently adulterated ?

By whom was strychnia discovered ?

Peltetier and Caventou in 1818.

Where is this alkali found ?

In the nux-vomica, and in the upas tree of the island of Java.

Is it ever poisonous ?

It is one of the most violent vegetable poisons known, its action is always accompanied by symptoms of locked jaw.

By whom was Sanguinaria discovered ?

Mr. Dana, it was found in the blood root, (*Sanguinaria canadensis*).

Of what color are its salts ?

The salts of sanguinaria are of a red color.

## LECTURE VIII.

### NEUTRAL PRINCIPLES.

Where is starch found?

It exists abundantly in the vegetable kingdom, and is obtained from farinaceous grains and roots.

What are some of its properties?

It is a white substance, insipid, inodorous, and is insoluble in alcohol, ether and cold water.

What effect does boiling water have upon it?

It converts it into a jelly, which is used for stiffening linen, and in cotton factories in the process of dressing.

What is a test of starch?

Iodine is the best test of starch.

How is it most generally made?

In Europe it is most commonly made from wheat, and in this country from potatoes,

What is the manner of preparing it from the potato?

The potatoes are rasped or ground, by a machine, to a pulp. This pulp when washed in water, yields a white powder, which on subsiding, proves to be a pure starch.



Are there any substances known in commerce which are merely varieties of starch ?

There are several varieties, the Indian arrow root, which is prepared from the root of the *Maranta arundinacea*, is a very pure starch. Sago prepared from the pith of an East Indian palm tree, and tapioca and cassava, from the root of a plant, are nearly the same.

#### GUM.

Are there many varieties of gum ?

There exists in many plants certain sorts of gums, and sometimes in such abundance that they exude from the bark as a viscid liquid, and harden upon it such as we see on our peach and cherry trees.

What are some of the properties of gum ?

They have neither taste nor smell ; are generally colorless, transparent and insipid. The true gums are those which dissolve in water, either hot or cold, and form with it a thick mucilaginous solution.

What are the names of the principal gums ?

The most important gums are the gum arabic, gum tragacanth, and gum senegal.

What is gum arabic ?

It is the most common variety of gums, it is the concrete juice of several species of the mimosa, or acacia, native of Africa and Arabia.

How is it prepared and for what is it used ?

Add to one dram of gum arabic, double the quantity of water, stir the mixture occasionally and the gum will, after a few days, entirely dissolve in the water. This is often used instead of paste, glue, &c. It is also employed in calico printing as a thickening material for colors and mordants, and in finishing and dressing operations.

What are some of its properties ?

It occurs in small, rounded, transparent grains, which are sometimes colorless, and at others, yellow, red, or brown.

Are gum arabic and gum senegal very different ?

Gum senegal is obtained from the shores of the Senegal, it contains the same principles as the gum arabic but yields a thicker mucilage.

Does gum tragacanth differ from the pure gums ?

Gum tragacanth is also a vegetable exudation, and is well known as a stiffening material ; it exudes from the tragacantha, a shrub which grows in Greece and Turkey. It differs from the pure gum, and is tougher than the common gum which is quite brittle.

Can you give an experiment with tragacanth ?

Let a piece of tragacanth remain for some days in cold water, it will soften and swell in-

to a stiff, viscid jelly. A single dram of it is sufficient to convert one pound of water into a thick mucilage.

What are some of the uses of gums ?

Gum, in the state of mucilage, is employed to give firmness and lustre to linen. It is used by calico printers, to give their colors such a degree of consistency as will prevent them from running upon the cloth, it is made to form an ingredient in writing ink, &c.

What is Pectine ?

The juices of many fruits and roots, for instance, currants, goose-berries, cherries, apples, carrots, &c., contain a peculiar kind of mucus, which communicates to the juice the property—especially when boiled with sugar—of hardening into a gelatinous mass after cooling. This mucus, to which the stiffening of the juice is to be ascribed, has received the special name of pectine, vegetable jelly.

#### SUGAR.

Are there many varieties of sugar ?

There are ; the chief of which are common or cane sugar, and grape sugar.

Is sugar a native production ?

It is an abundant vegetable product, existing in a great many ripe fruits, in the juice of the maple, beet root, &c.

How is our common sugar obtained ?

It is prepared in the tropical regions, from the juice of the sugar cane (cane sugar) or in France and Germany from the juice of the beet,—beet sugar.

How is sugar obtained from the cane ?

By evaporating the juice of a moderate ebullition, until the syrup is sufficiently thick to crystallize on cooling. During this operation lime water is added, partly for the purpose of neutralizing free acid, and partly to remove impurities which rise with the lime in a scum to the surface ; it is then drawn off into shallow wooden coolers, where it becomes a soft solid, it is then put into barrels with holes in the bottom, through which molasses gradually runs out, leaving raw or brown sugar.

How is raw sugar purified ?

It is done by redissolving the raw sugar in a little water, then filtering the brown solution through coarsely ground animal charcoal, which retains the coloring matter, &c. The clarified juice is then received into conical earthen vessels, the apex of which is undermost, in order that the fluid parts may collect there, and be afterward drawn off by the removal of the plug.

How is it purified ?

By boiling a solution of it with white of egg, or bullock's blood and lime water.

What is it then called ?

It then receives the name of loaf or refined sugar.

What are some of the properties of pure sugar ?

Pure sugar is solid, white and inodorous, and of a very agreeable taste. It is hard and brittle, and when two pieces are rubbed together in the dark, phosphorescence is observed.

How can it be obtained in crystals ?

By fixing threads in a syrup which evaporates gradually in a warm room, in this state, it is called rock candy.

How can sugar of starch be prepared ?

This species of sugar may be prepared in two ways ; either by boiling with diluted sulphuric acid (syrup of starch) or by digesting the starch with malt or distaste (malt syrup). These syrups may be regarded as concentrated solutions of sugar in water. Starch sugar is formed also in many vegetables, and is especially abundant in fruits, as for example, in plums, cherries, pears, figs, grapes, &c.

What is said of grape sugar ?

Grape sugar contains rather less carbon than common sugar, and is more generally diffused in nature. It gives to most fruits their sweet taste, and forms the solid part of honey.

Of what does honey consist ?

It consists of two kinds of sugar, one of which, when separated, crystallizes; and the other is uncrystallizable. It also contains gum and probably an acid; when diluted with water, honey undergoes the vinous fermentation.

What is manna?

It is the concrete juice of several species of ash growing principally in Italy.

How is Gluten obtained?

It is procured from wheat flour, by washing out the starch and boiling the remainder in alcohol.

What are some of its properties?

It has scarcely any taste, is insoluble in water, alcohol, and ether; when kept warm and moist it ferments.

What causes the rising of bread?

It is caused by the fermentation of gluten.

## LECTURE IX.

### OILS

By what are the oils characterized ?

Their peculiar unctuous feel, their inflammability, and by being insoluble in water.

How are they divided ?

The oils are divided into the fixed and volatile oils.

How are they obtained ?

They are usually found in the seed of plants, as for example, in the almond, linseed, rapeseed and poppy seed.

What are some of the properties of the fixed oils ?

They are those which do not evaporate without decomposition, or chemical changes. They produce an unctuous stain, which is not discharged by heat.

Into how many kinds are the fixed oils divided ?

Two, the drying oils and the fat oils.

Why are they denominated drying oils ?

Because, they acquire the property of drying rapidly when the oil is heated in open vessels, in which process much oxygen is absorbed and carbonic acid and hydrogen given off.

Do they absorb oxygen rapidly?

They sometimes absorb oxygen so rapidly as to set fire to combustibles. Spontaneous combustion often occurs where cotton has been moistened with them.

For what are drying oils used?

Drying or varnish oils are used for paint, and when mixed with lamp-black constitute printers ink.

What are some of the most important of the fixed oils?

Linseed, oil of walnut, oil of hempseed, castor oil, olive oil and croton oil.

From what is linseed oil obtained?

From the seeds of the common flax, and it is used most frequently in oil varnishes. Linseed oil and lime water has been found an excellent antidote for burns.

From what is the oil of walnuts obtained?

It is procured from the common walnut.

From what is the oil of hempseed procured?

The common hemp, it is also used in the preparation of varnish and likewise for burning and the manufacture of green soap.

How is castor oil obtained?

It is procured from the seeds of the castor oil plant. Its use in medicine is well known.

How is olive oil procured?

It is prepared from the common olive, by



bruising the seed, and subjecting the pulpy matter to pressure in hempen bags, a gentle heat being generally employed at the same time to render the oil more limpid.

From what is poppy oil obtained ?

Poppy oil is prepared from poppy seeds, serves as a table oil, and for the preparation of a very clear varnish.

How is croton oil obtained ?

From the fruit of the croton tiglium of the East Indies, and possesses powerful purgative properties.

#### FAT OR UNCTUOUS OILS.

What are fat oils ?

The term fat oils has been given to that kind of oils which are unctuous to the touch and are thick flowing.

What are some of the properties of fats ?

They spread with great ease upon paper and all other porous substances, as for instance wood, leather, &c., they float upon water and accordingly have a less specific weight than water. Preserved fruits keep much longer when melted butter is poured over them.

How is oil for burning prepared ?

It is expressed from the rape seed, and in order that it may burn without depositing soot on the wick, it must be refined, that is puri-

fied from slimy parts. This is done, not by oxide of lead, but by sulphuric acid.

How is the oil of almonds obtained?

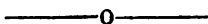
The oil of almonds is obtained by subjecting sweet almonds to pressure. Bitter almonds also yield by cold pressure a good oil of almonds, while by hot pressure an oil is obtained containing prussic acid.

How is cocoa nut oil obtained?

It is procured from the meat of the cocoa nut, it has a white color and a somewhat disagreeable smell.

How is palm oil obtained?

From the fruit of a species of palm tree.



## LECTURE X.

### FATS AND ALKALIES (SOAPS).

Do the fat oils unite with the alkalies?

They do, and form soap.

How many varieties of soap are there in commerce?

Three, hard white soap, hard yellow soap, and soft soap.

How is hard white soap made?

From tallow and caustic soda, which are boiled together.

Of what is hard yellow soap made?

Soda, tallow and some coarse oil and rosin.

How is soft soap made?

It is made by boiling together some fatty matter and impure caustic potash, prepared by lixiviating common wood ashes.

Upon what does the hardness or softness of soap depend?

The hardness of soap depends chiefly upon the alkali used, soda forming hard soap, and potassa soft.

Of what do the fats consist?

The fats consist of several simple, sometimes solid, sometimes fluid, kinds of fat—among which the solid stearine and the fluid oleine are especially predominant.

What does every simple fat contain?

A peculiar acid, thus stearine, stearic acid; oleine, oleic acid, palmitine, palmitic acid, &c., but all contain one and the same base.

How many important properties have soaps?

Two, 1st. They dissolve fat and oils; 2d. They are very easily resolved, nearly by mixing with much water, into an acid salt and free alkali; the latter dissolves most organic substances, but the former effects by its lubricity an easy washing away of the dissolved matter from other substances.

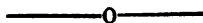
Can you give an experiment with soap and alcohol?

Pour one ounce of alcohol upon one ounce of the shavings of tallow soap ; the soap is completely dissolved on heating it in the water bath, but the solution congeals on cooling to a transparent jelly. This jelly-like soap, mixed with camphor and ammonia, is called opodeldoc.

What is said of the insoluble soaps ?

If lime water is added to a solution of soap in water, a precipitate of insoluble lime soap is formed, this is the reason why spring water which generally contains lime, neither dissolves soap nor lathers with it, and accordingly cannot be used for washing.

X



## LECTURE XI.

### VOLATILE OILS.

What are the volatile or essential oils ?

They are those which evaporate, or may be distilled, without change by a moderate heat.

To what do aromatic plants owe their odor ?

Aromatic plants owe their peculiar flavor and odor, to the presence of these oils, which are obtained from their different parts, as the flowers, leaves, stem, bark, or roots, by careful distillation ; water being put into the still along with the plants, in order to prevent them from burning.

What are some of the most interesting of the essential oils ?

Turpentine, caraway, cloves, pepper-mint, nutmeg, lavender, cinnamon, citron, and camomile.

Which of the oils do we obtain from the flower ?

Oil of roses, oil of orange flowers, oil of camomile, oil of lavender, and oil of cloves.

Which of the oils do we obtain from seeds and fruits ?

Oil of cumin, oil of anise-seed, oil of fennel, oil of dill, oil of nutmeg, oil of bitter almonds, oil of mustard, oil of juniper, laurel oil, oil of savin, oil of parsley, oil of lemons, oil of orange peel, and oil of bergamot from the rind of the bergamot orange, a pale yellow, very thin liquid.

Which of the oils do we obtain from the leaves and branches ?

Oil of balm, pale yellow, has an odor like that of lemons, oil of majorain, oil of thyme, oil of sage, oil of wormwood, oil of rue, oil of cinnamon, &c.

What is said of the oil of pepper-mint?

It is a very thin, colorless or yellowish liquid now frequently exported to Europe from America.

From what do we obtain Cajeput oil?

From the leaves of a tree growing in the Moluccas; the oil when pure is colorless; the crude oil is commonly green, and often contains camphor.

What is Camphor?

It is a volatile oil, solid at common temperatures, and it is obtained from the trunk and branches of the *Laurus camphora* of Japan, by distillation.

What are some of its properties?

It is a solid white substance, has a pungent odor, bitter aromatic taste, and is insoluble in water, but dissolves freely in alcohol, forming the common tincture of camphor.

What is said of the oil of turpentine?

It is the most common of the volatile oils, and is procured by distillation from common turpentine, a substance which exudes from incisions made in the wood of several species of the genus *Pinus*.

What are some of its uses?

It is employed in the preparation of varnishes, and for some medical and chemical purposes.

Why does turpentine take out grease spots

from cloth ?

Because turpentine dissolves the fixed oils.

Are there any oils obtained from the roots of plants ?

There are several, among which are, the oil of acorns, the oil of valerian, &c.

What are some of the properties of the volatile oils ?

These oils are all volatile at average temperatures, except camphor, which begins to melt at  $175^{\circ}$  C. but below this temperature it forms a white, solid, crystalline mass. The volatile oils when cooled, there is frequently separated from them a beautifully crystallized solid, white, camphor-like substance, which has been called *stearoptene*, in opposition to the liquid portions that remain which are called *ekoptene*.

Into how many classes are the volatile oils divided ?

Three, into the non-oxygenated oils, the oxygenated oils, and the sulphuretted oils.

Can you give an experiment with one of the volatile oils and water ?

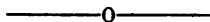
Drop some oil of cumin upon water, and the oil will float upon the surface, without mixing with the water—for most of the volatile oils are lighter than water—but there are some such as oil of cinnamon, oil of cloves, and bitter almonds, which are heavier and consequently sink in it.

Can you give an experiment with one of the

volatile oils and alcohol?

Experiment:—If some drops of bergamot, orange flower, lavender, or rose-mary oils are dissolved in half an ounce of strong alcohol, we obtain a spirit of a very pleasant odor. In a similar way the innumerable kinds of perfumed waters are prepared, at the head of which stands the well known *eau de Cologne*.

End X



## LECTURE XII.

### RESINOUS SUBSTANCES.

What are resins?

They are the inspissated juices of plants, and commonly occur either pure or in combination with an essential oil.

What are some of their properties?

They are solid at common temperatures, brittle, inodorous, and insipid; are non-conductors of electricity, and when rubbed become negatively electric; they are generally of a yellow color, and semi-transparent. They are soluble in alcohol, ether, and the essential oils.

What are some of their uses?



Various resinous substances are employed in the arts. Melted with wax and oil, they constitute ointment and plasters, combined with oil or alcohol, they form different kinds of oils and spirit varnish.

How are they prepared ?

Spread a little turpentine upon a board, and put it for some time near a heated stove ; the oil of turpentine evaporates, but the resin remains behind as an amorphous brittle mass. In some countries, incisions are made through the bark of the pine trees, and the turpentine which exudes, is allowed to evaporate on the trees themselves, and after it has been purified by melting and straining, it is brought into the market under the name of resin, white pitch or Burgundy pitch.

Which are some of the most important of them ?

The common resin, or rosin, copal, lac, sandarach, mastic, elimi, dragon's blood, and a few others.

What is tar ?

When turpentine is extracted from the wood of the fir tree by heat, it is commonly denominated tar.

What constitutes pitch ?

Pitch is tar inspissated by boiling or burning.

What is Copal ?

Copal is of a yellowish white color, turning

to brown, and very hard. The copal of the West Indies and Africa has a smooth surface, but that of the East Indies is wrinkled and uneven. It is insoluble in common alcohol, but soluble in ether.

Where is Lac found ?

Lac exudes from several species of *Ficus*, which grow in the East Indies.

Where is Sandarach obtained ?

It is the product of an evergreen tree which grows in Africa.

Where is Mastic found ?

Mastic is yellowish, transparent, and exudes from a species of pistacia, a tree growing principally in Greece.

What are some of the properties of shellac ?

It is of an orange color, very hard and tenacious, and for this reason it is generally used in the manufacture of sealing wax.

From what is Dragon's blood procured ?

Dragon's blood is a brownish red colored resin, and is the produce of several palm trees which grow in the East Indies.

From what is Guaicum procured ?

Guaicum, a brownish green resin, is obtained by roasting quaicum-wood, and it is considerably used in medicines.

What are balsams ?

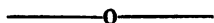
They are the juices of some kinds of trees, and are compounds of resins and benzoic acid.

What is amber ?

It is a fossil substance, consisting of a peculiar bituminous matter and resin.

Where is it found ?

It is undoubtedly of vegetable origin, and is found abundantly on the southern coast of the Baltic sea, and to some extent on the Yorkshire coast, England, and in some parts of the United States. Its hardness and tenacity are well known, since it is formed into various articles which are usually manufactured from glass or horn.



## LECTURE XIII.

### RESINS AND GUM RESINS.

What are the properties of resins ?

They do not undergo decay, and on this account they were formerly used for embalming dead bodies, which are now found dried to mummies. They are insoluble in water, and therefore tasteless.

Do any of the resins contain water ?

Many of them do, and are thereby rendered dull and opaque; common pine resin and boiled turpentine furnish examples of this.

How are they rendered fluid?

Most of them require heat, which is somewhat higher than that of boiling water, in order to become fluid.

Are they ever used for making vessels airtight?

They are, the wood work of ships, the hatches, &c., are covered with tar to keep out the sea water and rain. Iron rails and iron ornaments are covered with a coating of pitch, to prevent them from being so quickly oxidized by the oxygen of the air.

Of what is sealing wax made?

It is composed of lac, venice turpentine, and common rosin. Take one fourth of an ounce of pale shellac, one dram of turpentine, one dram of cinnabar, and three-fourths of a dram of prepared chalk, and melt them together. Then while it is yet warm, roll it out in sticks by the hands, moistened with water. The turpentine renders it more inflammable, and the composition is colored black by means of lampblack, or red by cinnabar.

Of what is lampblack composed?

It is the soot procured from the combustion of resinous wood, turpentine or resin.

What is burnt pitch?

If rosin, after it is burnt for some time, is extinguished by putting a board over it, we shall have as a residum a black, burnt resin, ship pitch and shoemakers wax, possessing great tenacity.

What are gum-resins?

They are the concrete juices of certain plants, and consist of resin, essential oil, gum, and extractive vegetable matter. The two former principals are soluble in alcohol, and the two latter in water.

Are the gum resins numerous?

They are, and many of them are valuable medicines; among which are aloes, assafoetida, galbanum, gamboge and myrrh.

What are some of the properties of aloes?

Aloes has a brown or black color, and is exceedingly bitter. it is the dried juice of the aloe plant, which grows in great abundance on the Cape of Good Hope and its vicinity.

What are some of the properties of assafoetida?

It is the juice of a Persian umbelliferous plant, it has a very unpleasant smell like that of garlic.

From what is galbanum obtained?

It is of a yellowish brown color, has a strong odor, and is obtained from an evergreen plant of Persia.

Where is Gamboge found?

It is obtained from the leaves of an East Indian plant, and is principally used as a yellow water color in painting.

Where is Myrrh found ?

Myrrh is of a brownish yellow color, has a bitter taste, balsamic odor, and exudes from incisions made in a tree growing in Arabia.

Where is opium found ?

Opium is a milky juice, which exudes from incisions made in the heads of unripe poppies, and is inspissated by exposure to the air ; it occurs in large lumps of a dark brown color, having a bitter taste and an offensive narcotic odor.

By what name is Caoutchone commonly called ?

Caoutchone, or India rubber, is obtained from four species of trees, two of which grow in south America, and two in the East Indies.

What is Gutta Percha ?

It is a substance resembling caoutchone, has occurred in commerce, which is procured from the milky juice of several East Indian trees, it becomes soft and plastic by heating, but hard again on cooling, it has already been found useful in the arts.

What are some of the properties of India rubber ?

It is a solid of a whitish color when not blackened by smoke ; possesses considerable

tenacity, and is particularly remarkable for its elasticity. It is inflammable and burns with a bright flame. It is insoluble in water and alcohol ; but it dissolves, though with some difficulty in pure ether ; it is soluble in pure petroleum, cajeput oil, purified naptha, and the oil of sassafras.

What are some of its uses ?

It is inflammable, and has been used by the inhabitants of Cayenne, for lights. The solutions have been used for varnishes. It is also of great use in the formation of many instruments which require to be elastic, and impenetrable to water. Shoes are made of it in great numbers, and are found to exclude perfectly the wet. The solution of this gum upon leather and cloth, renders them water-proof, and even air tight.

What are the properties by which it erases black lead from paper ?

The adhesiveness and friction of India rubber are the properties by which black lead is erased from paper.

What is wax ?

It is an abundant vegetable production, entering into the composition of pollen of flowers and covering the envelope of the plumb and other fruit.

What are some of its properties ?

In its common form it is always more or less

colored ; but when pure, it is colorless and insipid. It is solid at ordinary temperatures, but melts with a gentle heat at  $142^{\circ}$  Fahrenheit, is inflammable, dissolves in boiling alcohol, ether and the fixed oils, but is insoluble in water.

How is bee's wax deprived of its coloring matter ?

By bleaching, the wax is melted and suffered to run through a vessel containing holes, upon the surface of a cylinder, which is kept revolving in water, by which means the wax is spread out and cooled in the form of thin laminae, or ribbons. It is then exposed to the light and air upon frames, and occasionally wet till the bleaching is completed.

Of how many portions does wax consist ?

According to Dr. John it consists of two portions, one of which is soluble in alcohol, the other not. To the former he has given the name of cerin, and to the latter myricin.



## LECTURE XIV.

### BITUMINOUS SUBSTANCES.

What is naphtha

It is a liquid which exudes from the earth in some parts of Italy, and in Persia.

What are some of its properties?

It has a strong peculiar odor, is generally of a yellowish color, but may be rendered perfectly limpid by distillation.

Where is Petroleum found?

In several parts of the world. It occurs particularly in cool districts.

What are some of its properties?

It is of a reddish brown color, unctuous to the touch, and less limpid than naphtha.

Where is Asphaltum found?

On the banks of the Dead Sea, and occurs in large quantities in Barbadoes and Trinidad.

What are some of its properties?

It is a solid, brittle bitumen, of a black color, vitreous lustre, and conchoidal fracture. It melts easily, is very inflammable, and emits a bituminous odor when rubbed, and by distillation yields a fluid like naphtha.

How is Creosote obtained?

From pyrolignous acid, but it is best prepared from those portions of the oil distilled from wood tar, which are heavier than water.

What are some of its properties ?

It is a colorless, transparent liquid of an oily consistence, has a burning taste followed by sweetness, and its odor is like that of wood smoke, or rather smoked meat. It is highly antiseptic to meat.

What are some of its uses ?

It is considerably used in medicine, both internally and externally. When placed upon the tongue, it occasions violent pain, and when poured in a concentrated state upon the skin, it cures epidermis.

How many kinds of mineral coal are there ?

Two, bituminous coal, and stone coal or anthracite.

How is bituminous coal distinguished ?

By its softening like wax when thrown upon burning coals, and giving off much gas when heated, which of course burns with flame.

How does anthracite differ from common coal ?

In containing no bituminous substances, and in not yielding inflammable gases by distillation.

Where is anthracite found ?

In different countries, but most abundantly

in the state of Pennsylvania, which supplies most of the northern and eastern parts of the United States.

Where is gas used extensively at the present day?

It has been introduced very extensively into almost all of our cities, and is used for illuminating the houses and streets. It appears to have been first introduced by Mr. Murdock, in 1792.

How is it prepared?

By the distillation of oleaginous and resinous substances, and bituminous coal.

How is coal gas prepared?

By heating coal to redness in iron retorts. Gas formed from coal has always to be cleansed from hydro-sulphuric acid, by passing it through milk of lime, before it is fit for use.

*General Principles of the Art*

## LECTURE XV.

### COLORING MATTERS.

What are some of the most common colors in the vegetable kingdom?

Green, yellow, blue and red.

How have the coloring substances been divided?

Into substantive and adjective colors.

What are substantive colors?

They are those which communicate their tint immediately to the material to be dyed, without the intervention of a third body.

What are adjective colors?

They are those which require the intervention of a third substance, which possesses an attraction for both the cloth and the coloring matter.

What is the substance called which fixes the colors?

It is denominated a mordant or basis.

Are the agents numerous which are capable of acting as mordants?

They are, but those which are principally employed in practice are the acetate of alumina, the sulphate or acetate of iron, and the muriate of tin.

Are the coloring substances used in dying numerous?

They are, but the most important of them are indigo, madder, guercitron, &c.

#### BLUE DYES.

What is the chief substance used for giving the blue dye.

Indigo, and it is obtained from a plant cultivated in warm climates. It is cut a short time before it flowers, and put into large vats covered with water; fermentation then spontaneously ensues, during which the indigo subsides in the form of a pulvernulent, pulpy matter. Its color is at first green, but by exposure to the air, it absorbs oxygen and becomes blue.

What are some of its properties?

It is a light brittle substance, of a deep blue color, it is tasteless and destitute of odor; is insoluble in water, and but slightly soluble in boiling alcohol; it is soluble in sulphuric acid.

What is the process of sublimation?

••• The process of subliming indigo is one of great delicacy, owing to the circumstance that the temperature at which it sublimes, is very near that at which it is decomposed.

When cloth is dipped into a solution of de-oxidized indigo, what color does it receive?

Green, which becomes blue by exposure to the air.

What are the chief substances employed in giving red dyes ?

Madder, cochineal, archil, brazil-wood, log-wood, and safflower, all of which are adjective colors.

What is madder ?

It is one of the most valuable drugs in the art of dying, it is the root of the *Rubia tinctorium*, a plant extensively cultivated in Europe, and particularly in Holland. By the different use of mordants, it is made to produce every shade of red, purple, and even black.

Can calico printing be stamped with several mordants ?

A piece of calico may be stamped with several mordants, which are the basis of different colors, and upon immersing it in a madder bath as many colors will appear as there are mordants used.

How is cochineal obtained ?

It is procured from an insect, which feeds upon several varieties of cactus, and is supposed to derive this coloring matter from its food.

What are some of the properties of cochineal ?

It is very soluble in water, and is fixed on cloth by means of alumina or oxide of tin. Its natural color is crimson, but when bitartrate of potassa is added to the solution, it yields a

rich scarlet dye.

Where is archil found ?

It is procured from a kind of lichen, ( *Lich-  
er rocella* ) which grows chiefly in the Cana-  
ry Islands, and is employed by the Dutch in  
forming the blue pigment called litmus.

What are some of the uses of litmus ?

It is used in dying, and is employed by che-  
mists as a test for detecting the presence of a  
free acid.

Where is Brazil-wood obtained ?

Brazil-wood is found in the heart wood of  
several trees, growing in South America, and  
imparts to different materials a beautiful red  
color.

What is logwood ?

It is a dense, heavy wood, and grows in the  
tropical parts of America. It is of very great  
use to dyers. The violet color of logwood is  
fixed by alum, and a blue is obtained from it  
by verdigris.

From what is safflower obtained ?

Safflower, the flowers of the dyer's saffron,  
are used for obtaining a brilliant rose color for  
pink saucers.

#### YELLOW DYES.

What are the chief yellow dyes ?

The chief yellow dyes are the quercitron,  
bark, turmeric, hickweld, fustic and saf-  
fron, all adjective colors.

Where is the quercitron found?

It is obtained from the bark of the black oak, a tree of North America, it is a nankeen yellow powder, mixed with fibrous fragments, and is soluble in water.

Where is Turmeric found?

Turmeric is the root of a plant growing in the East Indies, is very rich in a resinous yellow dye, which is colored brownish-red by alkalies.

Where is fustic found?

Fustic is the rasped trunk-wood of a mulberry-tree growing in the West Indies.

Where is saffron found?

Saffron consists of the dried stigmas of the flowers of the crocus sativus. Its application, in coloring articles of food and cordials yellow, is well known.

#### BLACK DYES.

Of what are the black dyes made?

Of the same ingredients as writing-ink, and therefore consists essentially of a compound of oxide of iron with gallic acid and tannin. By the addition of logwood and acetate of copper, the black receives a blue shade.

What are lakes?

They are insoluble compounds of coloring matter with alumina, or oxide of iron or tin.



## LECTURE XVI.

### X SPIRITUOUS AND ETHEREAL SUBSTANCES.

What is alcohol ?

It is the product only of fermentation, and is never found ready formed in any vegetable substances.

What are the elements of which alcohol is composed ?

Carbon, Oxygen and Hydrogen.

How is it obtained ?

By the distillation of ardent spirits.

What are some of its properties ?

It is a colorless fluid, of a penetrating odor, and burning taste, highly inflammable, and burns with a yellowish blue flame. No smoke is produced in its combustion, and hence it is of great utility for lamps in a laboratory.

What are some of its uses ?

It is used in cabinets of natural history, for the preservation of specimens of fishes, reptiles, &c. As a solvent alcohol is very useful. It is the intoxicating ingredient of every variety of spirituous and vinous liquors ; taken internally, it operates, and is well known as a powerful stimulant; and various alarming diseases, often terminating in extreme moral degradation and death, attend its habitual use.

ETHERS.

How are ethers formed?

It is the name applied to a numerous class of compounds, formed by distilling a mixture of alcohol with the different acids.

What are some of the most important of this class of bodies?

Sulphuric ether, hydrochloric ether, hyponitrous ether, oxalic ether, and acetic ether.

How is sulphuric ether prepared?

Sulphuric ether is the most common, and is prepared by boiling equal weights of alcohol and sulphuric acid; it has been known for several centuries.

What are its properties?

It is a colorless fluid, of a hot pungent taste, and fragrant odor; it combines with alcohol in all proportions, but not with water; it is highly inflammable, burning with a blue flame, and forming carbonic acid and water.

How is pure ether prepared?

By mixing gradually equal parts of strong sulphuric acid and alcohol, and subjecting the mixture to slow distillation, into a receiver surrounded by ice, by a carefully regulated heat.

Of what is ether supposed to consist?

Two proportions of olefiant gas, and one proportion of water.

**342 SPIRITUOUS AND ETHEREAL SUBSTANCES.**

**What are some of the properties of pure ether?**

It is a colorless limpid liquid, of a hot pungent taste, and fragrant odor, it is highly inflammable, burning with a yellow flame, with oxygen gas, its vapor forms a mixture which explodes violently on the approach of flame, or by the electric spark.

**How is hydrochloric ether prepared?**

By distilling alcohol previously saturated with hydrochloric acid gas.

**What are some of its properties?**

It is a colorless liquid, and burns with an emerald green flame, without smoke.

**By what name is hyponitrous ether frequently called?**

Nitric, and nitrous ether, and is formed by distilling a mixture of strong nitric acid and alcohol.

**What gives wines their peculiar odor.**

Oenanthic ether and it is obtained in the distillation of wine. The ether is separated by distillation, and produces intoxication when inspired.

**What are the properties of acetic ether?**

It is volatile, is heavier than most other ethers, and burns with a yellowish white flame, and during its combustion acetic acid is developed.

*Hyponitrous ether*

## LECTURE XVII.

### FERMENTATION.

When vegetable substances are exposed to warmth, what becomes of them?

They undergo spontaneous changes, and the process is called fermentation.

### SACCHARINE FERMENTATION.

What substance is known to be subject to this kind of fermentation?

Sugar is the only substance, and the products of it are always alcohol and carbonic acid. The conditions necessary to this process are, the presence of sugar, water, yeast or some ferment, and a certain temperature. In the fermentation of bread, the saccharine matter of the flour is resolved into alcohol and carbonic acid gas, the latter causes the dough to rise, and the former is entirely expelled by the heat of baking.

What is yeast?

It is a substance always generated during the vinous fermentation of vegetable juice and decoctions, rising to the surface in the form of a frothy, flocculent, somewhat viscid matter, the nature and composition of which are unknown.

How is barley malted

Barley is heated up and moistened with water.

Why is yeast needed to make malt into beer?

Because a putrifying body containing nitrogen, is essential in order to convert sugar into alcohol.

How is beer manufactured?

By digesting malt, previously ground, with its weight of warm water, for several hours.

Why is beer flat if the cask is left open long?

Because too much of the carbonic acid is suffered to escape.

How is brandy procured?

From the fermented juice of the grape, or wine.

How is rum procured?

From the fermented juice of sugar cane.

How is clear wine procured?

The grapes are pressed, the juice is then poured into vats, and allowed to remain in the cellar, where the fermentation proceeds very slowly, as the temperature is tolerably low

How is red wine prepared?

Purple grapes are bruised for the manufacture of red wine, then fermented with their skins and stalks, and sparkling wine, (or Cham

pagne), is made by letting the fermentation proceed in corked up bottles, whereby the carbonic acid formed is retained in the wine.

Why does milk turn sour by keeping ?

Because it undergoes fermentation during which lactic acid is formed which turns the milk sour.

In what way is acetic fermentation produced ?

When any liquid which has undergone the vinous fermentation, or even pure alcohol diluted with water, is mixed with yeast and exposed in a warm place in the open air, an intestine movement speedily commences, heat is developed, and the fluid becomes turbid from the deposition of a peculiar filamentous matter. Oxygen is absorbed from the atmosphere. These changes, after continuing for a certain time, cease spontaneously ; the liquor becomes clear, and instead of alcohol, it is now found to contain acetic acid.—T.

In what does putrefactive fermentation result ?

In complete destruction.

Are all vegetable substances subject to putrefaction ?

Many of them are not subject to putrefaction.

## LECTURE XVIII

### ANIMAL CHEMISTRY.

What is said of animal substances

They are less permanent than those of vegetable origin, and when life becomes extinct, they undergo a spontaneous change, and resolve themselves into new modes of combination.

Can animal substances be easily distinguished from vegetable?

They cannot, but the former may be known by the peculiar and offensive odor given off by them during their combustion.

Of what does fibrin form the basis?

Of the muscular or fleshy parts of animals, and is left, combined with albumen, when all the soluble parts, consisting of gelatin, osmazome, fat, and various salts, have been washed away by hot water.

What are some of its properties?

It is solid, white, insipid and inodorous. In a moist warm situation, it readily putrifies, is insoluble in water at common temperatures, but is dissolved by the continued action of boiling water.

## ALBUMEN.

Does albumen enter largely into the composition of animal fluid?

It does both of animal fluids and solids.

Where is liquid albumen found?

In the serum of the blood, the liquor of serous cavities, the fluid of the dropsy, and the white of eggs.

From what is liquid albumen the best prepared?

The white of eggs, which consists almost solely of this principle, united with water and free soda.

## GELATIN.

Where is gelatin found?

It exist abundantly in many of the solid parts of the body, especially in the skin, cartilages, tendons, membranes and bones.

How is it distinguished from all animal principles?

By its ready solubility in boiling water, and by the solution forming a bulky, semi-transparent, tremulous jelly as it cools.

What are some of its properties?

It is insoluble in alcohol, but readily dissolved by most of the diluted acids.



By what name is the gelatin of commerce commonly known?

Glue.

How is it prepared?

By boiling in water the cuttings of parchment, or the skins, ears and hoofs of animals, and evaporating the solution.

How is isinglass prepared?

From the sounds of fish, and it is the purest kind of gelatin.

From what is the animal jelly of the confectioners made?

The feet of calves, the tendinous and ligamentous parts of which yield a large quantity of gelatin.

Of what do bones consist?

Earthy salts and animal matter intimately blended, the former of which are designed for giving solidity and hardness, and the latter for agglutinating the earthy particals.

What are animal substances?

They are chiefly cartilage, gelatin, and a peculiarly fatty matter called marrow. On reducing bones to powder, and digesting them in water, the fat rises and swims upon its surface, while the gelatin is dissolved.

Of what are teeth composed?

Of the same materials as bone; but the enamel dissolves completely in dilute nitric acid,

and therefore is free of cartilage. The composition of ivory is similar to that of the bony matter of teeth in general. The shells of eggs, and the covering of crustaceous animals, such as lobsters, crabs, and the star fish, consist of carbonate and a little phosphate of lime and animal matter.

Of what do the shells of oysters consist?

The shells of oysters, muscles, and other moluscous animals, consist almost entirely of carbonate of lime and animal matter; and the composition of pearl, and mother of pearl, is similar.

Of what does horn consist?

Gelatin and a cartilaginous substance like coagulated albumen. The composition of the nails and hoofs of animals is similar to that of horn.

Of what are tendons composed?

They appear to be composed almost entirely of gelatin; they are soluble in boiling water, and the solution yields an abundant jelly on cooling.

Of what are membranes and ligaments composed?

Chiefly of gelatin; but they also contain some substance which is insoluble in water, and is similar to coagulated albumen.

Have animal oils any properties in common with those derived from the vegetable kingdom?

They have many properties in common with those derived from the vegetable kingdom, and are probably the same, but both have some peculiarities.

What are their ultimate elements ?

Carbon, hydrogen and oxygen.

How is train oil obtained ?

By means of heat, from the blubber of the whale; and it is employed extensively in making oil gas for burning in common lamps.

What are some of its properties ?

It is of a reddish yellow color; emits a strong, unpleasant odor, and has a considerable degree of viscosity, which renders it unfit for being burned in Argand's lamps.

How is spermaceti oil obtained ?

From the fatty matter contained in the bony cavity of the head of the whale. On subjecting this substance to pressure in bags, a quantity of pure limpid oil is expressed, called spermaceti oil.

What are some of its properties ?

It is an inflammable substance, of a white color and silvery lustre, it is brittle, soft and slightly unctuous to the touch, and insoluble in water. It has no taste, and scarcely any odor.

Of what color is Hog's lard ?

It is a fat of nearly white color, and is used for domestic purposes.

What is suet?

It is a term applied to that fat situated about the loins and kidneys, which is less fusible than the fat from other parts of the same animal. The suet from beef and sheep is principally used.

How is fish oil obtained?

Fish oil is tried out from the fat of whales, dolphins, &c., it is used for greasing leather, in medicine, and in the preparation of black oil soaps.

## LECTURE XIX.

### ANTIDOTES FOR POISONS.

What is the best antidote for a person who has taken an overdose of hydrous sulphuric acid?

Dry magnesia; for if water is taken, it will produce a very great heat, and thus increase its injurious effects.

When a person has taken arsenic acid accidentally or intentionally what is the best remedy?

Perhydrate of iron with a small quantity of ammonia. In cases rapidly fatal, extreme faintness, cold sweats, attended with slight convulsions are experienced. The dose should not be less than ten or twelve times the weight of the poison that has been taken.

If a person feels faint from the fumes of prussic acid, what is the best antidote.

To smell the vapors of strong ammonia.

What should be done for a person who has swallowed prussic acid?

Apply hartshorn to the nostrils and immerse the back in cold water, the process if continued for a number of times, generally proves effectual.

When oxalic acid has been swallowed accidentally, what is the best remedy?

Copious draughts of lime water, or powdered chalk and water, should be administered, and vomiting excited as soon as possible.

If corrosive sublimate has been swallowed what is the best antidote?

Flour and water mixed to the consistence of a smooth paste, has frequently proved efficacious.

If an over dose of laudanum has been taken what is the best antidote?

Iodine, three grains, iodide of potassium, six grains; water one pint, to be given in doses of a wine-glass full.

Why is strong green tea unwholesome?

Because it contains prussic acid, which destroys the nervous system.

What is the best antidote to verdigris?

Sugar, or the white of egg.

If chlorine gas has been inhaled immoderately, what is the best antidote?

To be removed in the fresh air, and apply ammonia to the nostrils.

Has ammonia ever been found injurious?

Orfila adds a caution against its too frequent use with persons who have fainted. If they breathe it too long, the vapor inflames the throat and lungs, and thus produces death.

What is a good remedy for an over dose of arsenic?

In case of poisoning by arsenic, it is well to

administer milk, white of eggs, soap suds or sugar.

When the water of ammonia is taken in an over dose what is the best remedy?

Vinegar mixed in water, this neutralizes the ammonia, and renders it inactive.

What effect has an over dose of saltpetre?

It produces violent poisonous symptoms. Vomiting should be immediately induced by large doses of mucilaginous dilutent drinks, emetics which irritate the stomach should not be given.

# INDEX.

The numbers refer to the pages.

|                           |     |                             |     |
|---------------------------|-----|-----------------------------|-----|
| <b>A.</b>                 |     | Ulmic.....                  | 305 |
| Acetates.....             | 295 | Affinity, chemical.....     | 112 |
| Acetic, either.....       | 341 | "    single elective...     | 113 |
| Acids, definition of..... | 261 | "    double elective..      | 119 |
| sulphur.....              | 261 | Air, atmospheric.....       | 150 |
| vegetable.....            | 291 | composition of.....         | 151 |
| Acetic.....               | 293 | Albumen.....                | 346 |
| antimonious.....          | 303 | Alcohol.....                | 339 |
| antimonic.....            | 303 | burning of.....             | 339 |
| arsenic.....              | 276 | flame of.....               | 339 |
| arsenious.....            | 277 | lamp of.....                | 339 |
| benjoic.....              | 300 | Alkalies, definition of.... | 213 |
| boracic.....              | 196 | vegetable.....              | 304 |
| camphoric.....            | 301 | Alloys.....                 | 204 |
| carbonic.....             | 159 | of lead.....                | 205 |
| chloric.....              | 275 | of copper.....              | 204 |
| chromic.....              | 303 | of gold.....                | 206 |
| cinnamic.....             | 302 | of silver.....              | 205 |
| citric.....               | 296 | Almonds, oil of.....        | 317 |
| coconic.....              | 300 | Aloes.....                  | 328 |
| croconic.....             | 300 | Alum.....                   | 269 |
| gallic.....               | 299 | Alumina.....                | 221 |
| Acids.....                | 134 | Amalgamation, process of..  | 250 |
| hydrofluoric.....         | 194 | Amalgams.....               | 207 |
| lactic.....               | 345 | Amber.....                  | 328 |
| malic.....                | 295 | Ammonia.....                | 147 |
| margaric.....             | 303 | Anolysis, proximate.....    | 290 |
| metallic.....             | 300 | ultimate.....               | 290 |
| meconic.....              | 302 | Animal chemistry.....       | 366 |
| nitric.....               | 137 | life.....                   | 131 |
| oleic.....                | 302 | Anthracite.....             | 156 |
| oxalic.....               | 291 | Antimony.....               | 239 |
| prussic.....              | 301 | Archil.....                 | 339 |
| pyroligneous.....         | 295 | Arsenic.....                | 235 |
| selicic.....              | 198 | test for.....               | 236 |
| stearic.....              | 302 | white.....                  | 236 |
| succinic.....             | 300 | Arsenites.....              | 276 |
| sulphuric.....            | 139 | Asphaltum.....              | 332 |
| tannic.....               | 299 | Assaying.....               | 202 |
| tartaric.....             | 297 | Atmosphere.....             | 149 |
|                           |     | pressure of....             | 55  |



|                           |     |                             |     |
|---------------------------|-----|-----------------------------|-----|
| Atomic theory.....        | 119 | Carbonic acid.....          | 159 |
| Attraction, chemical..... | 112 | Carbonic acid as nutriment  |     |
| electrical.....           | 82  | of plants.....              | 159 |
|                           |     | " from respiration          | 159 |
|                           |     | " in the air.....           | 161 |
| <b>B.</b>                 |     | Cast iron.....              | 228 |
| Baldwin's phosphorus....  | 72  | Castor oil.....             | 315 |
| Balloons.....             | 33  | Cerium.....                 | 241 |
| Balsams.....              | 325 | Charcoal.....               | 157 |
| Barometers.....           | 49  | Chemical, combinations...   | 157 |
| Barium.....               | 216 | " properties.....           | 157 |
| Bell metal.....           | 204 | Chemistry, definition of..  | 13  |
| Benzoin.....              | 54  | " animal.....               | 345 |
| Bismuth.....              | 242 | " vegetable.....            | 290 |
| Bituminous substances.... | 332 | " organic.....              | 285 |
| Bleaching.....            | 177 | Chlorates.....              | 274 |
| Blow-pipe.....            | 141 | Chlorine.....               | 181 |
| Black-dyes.....           | 339 | Chokedamp.....              | 161 |
| Blue-dyes.....            | 335 | Cromates.....               | 277 |
| Block-tin.....            | 332 | Chromium.....               | 236 |
| Boiling-point.....        | 41  | Chrome, yellow.....         | 277 |
| Borates.....              | 279 | Cinnabar.....               | 249 |
| Borax.....                | 279 | Classification of metals... | 200 |
| Boron.....                | 195 | Coal, bituminous.....       | 332 |
| Brass.....                | 204 | Cobalt.....                 | 232 |
| Brazil-wood.....          | 337 | Cochineal.....              | 337 |
| Bromine.....              | 194 | Cocanut oil.....            | 317 |
| Bronze.....               | 204 | Coke.....                   | 156 |
|                           |     | Cold.....                   | 24  |
| <b>C.</b>                 |     | Coloring matter.....        | 335 |
| Cadmium.....              | 230 | Columbium.....              | 238 |
| Calcium.....              | 218 | Combustion.....             | 166 |
| Calico printing.....      | 337 | Condensation.....           | 61  |
| Caloric.....              | 18  | Copal.....                  | 324 |
| " absorption of.....      | 28  | Copper.....                 | 244 |
| " conduction of.....      | 19  | Couronne des tasses.....    | 96  |
| " conductors of.....      | 20  | Cream of tartar.....        | 298 |
| " distribution of.....    | 30  | Creosote.....               | 333 |
| " effects of.....         | 30  | Croton oil.....             | 316 |
| " radiation of.....       | 22  | Crucibles crystals.....     | 121 |
| " source of.....          | 59  | Crystallography.....        | 121 |
| " transmission of....     | 22  | Cyanogen.....               | 161 |
| Camphor.....              | 321 | Cube.....                   | 122 |
| Cane sugar.....           | 311 |                             |     |
| Canton's phosphorus.....  | 72  | <b>D.</b>                   |     |
| Caoutchouc.....           | 329 | Daguerreotype.....          | 74  |
| Carbon.....               | 154 | Davy's safety lamp.....     | 164 |
| Carbonates.....           | 280 | Decomposition of light....  | 64  |
|                           |     | Decipitation.....           | 263 |

|                           |     |
|---------------------------|-----|
| Definite proportions..... | 119 |
| Deflagrator.....          | 271 |
| Dew, formation of.....    | 26  |
| "    point.....           | 27  |
| Diamond.....              | 154 |
| Distillation.....         | 53  |
| Dodecahedron.....         | 123 |
| Double refraction.....    | 64  |
| Dragon's blood.....       | 325 |
| Dyeing.....               | 334 |
| Ductility.....            | 202 |
| Dufay's theory.....       | 84  |
| Dutch gold.....           | 204 |

## E

|                                         |     |
|-----------------------------------------|-----|
| Ebullition.....                         | 41  |
| Electricity.....                        | 75  |
| "    conductors of.....                 | 79  |
| "    induction of.....                  | 86  |
| "    theories of.....                   | 84  |
| Electrical machine.....                 | 77  |
| Electro-meter.....                      | 83  |
| Electro-magnetic <i>telegraph</i> ..... | 108 |
| Electro-magnetism.....                  | 106 |
| Elemes.....                             | 324 |
| Epsom salts.....                        | 268 |
| Ethers.....                             | 340 |
| Eudiometer.....                         | 151 |
| Evaporation.....                        | 44  |
| Expansion of bodies.....                | 30  |
| Explosive gas.....                      | 139 |

## F

|                           |     |
|---------------------------|-----|
| Fat of animals.....       | 318 |
| Fats.....                 | 316 |
| Fermentation, acetic..... | 344 |
| "    alcoholic.....       | 339 |
| "    of bread.....        | 342 |
| "    putrefaction.....    | 344 |
| "    saccharine.....      | 342 |
| "    vinous.....          | 343 |
| Fibrine.....              | 345 |
| Firedamp.....             | 164 |
| Fire.....                 | 158 |
| Flame.....                | 170 |
| Fluorine.....             | 193 |
| Frost.....                | 28  |
| Fustic.....               | 338 |

## G

|                                           |     |
|-------------------------------------------|-----|
| Gallic acid.....                          | 299 |
| Galvanism, theories.....                  | 97  |
| "    effects of.....                      | 98  |
| Gamboge.....                              | 328 |
| Garometer.....                            | 163 |
| Gas-lights.....                           | 304 |
| Gelaten.....                              | 346 |
| Germination.....                          | 287 |
| Gilding.....                              | 256 |
| Glass—green bottle, crown,<br>plates..... | 198 |
| Glaubers salts.....                       | 265 |
| Glucinum.....                             | 222 |
| Glue.....                                 | 347 |
| Gluten.....                               | 313 |
| Gold.....                                 | 253 |
| Graphite.....                             | 155 |
| Grape juice.....                          | 293 |
| Gum arabic.....                           | 308 |
| "    senegal.....                         | 309 |
| "    tragacanth.....                      | 309 |
| "    resins.....                          | 326 |
| Gun powder.....                           | 271 |
| Gutta percha.....                         | 329 |
| Gypsum.....                               | 125 |

## H.

|                        |     |
|------------------------|-----|
| Haloid salts.....      | 284 |
| Hartshorn.....         | 147 |
| Honey.....             | 312 |
| Humors of the eye..... | 68  |
| Hydrate's.....         | 144 |
| Hydrogen.....          | 138 |
| Hydrometer.....        | 47  |
| Hydro-salts.....       | 283 |

## I.

|                       |     |
|-----------------------|-----|
| Illuminating gas..... | 336 |
| India rubber.....     | 329 |
| Indigo.....           | 336 |
| Ink.....              | 233 |
| Iodine.....           | 190 |
| Iridium.....          | 260 |
| Iron.....             | 226 |
| Ivory block.....      | 157 |

## K.

|           |     |
|-----------|-----|
| Kelp..... | 281 |
|-----------|-----|

## L.

|                           |     |
|---------------------------|-----|
| Lac.....                  | 325 |
| Lamp black.....           | 157 |
| Lamp argand.....          | 173 |
| Lead.....                 | 246 |
| Leyden jar.....           | 85  |
| Light.....                | 62  |
| " theories of.....        | 66  |
| " decomposition of.....   | 65  |
| " diffusion of.....       | 63  |
| " reflection of.....      | 63  |
| Light, refraction of..... | 64  |
| " terrestrial.....        | 71  |
| " velocity.....           | 62  |
| Lime.....                 | 219 |
| Linseed oil.....          | 315 |
| Liquefaction.....         | 39  |
| Lithium.....              | 215 |
| Litmus.....               | 338 |
| Loadstone.....            | 102 |
| Logwood.....              | 337 |

## M.

|                           |     |
|---------------------------|-----|
| Madder.....               | 336 |
| Magnesium.....            | 219 |
| Magnetism.....            | 102 |
| Magnetic needle.....      | 103 |
| Magnetic electricity..... | 104 |
| Malic acid.....           | 295 |
| Malt.....                 | 283 |
| Manganese.....            | 225 |
| Manna.....                | 313 |
| Matches.....              | 180 |
| Mercury.....              | 249 |
| Metals.....               | 200 |
| Mineral pitch.....        | 324 |
| " tar.....                | 326 |
| Molasses.....             | 312 |
| Morphia.....              | 305 |
| Myrrh.....                | 329 |

## N.

|               |     |
|---------------|-----|
| Naptha.....   | 322 |
| Nickel.....   | 103 |
| Nitrates..... | 270 |
| Nitre.....    | 271 |
| Nitrogen..... | 145 |

|                            |     |
|----------------------------|-----|
| Nitrous acid.....          | 137 |
| Nitrous oxide.....         | 136 |
| Non-metallic elements..... | 130 |
| Nomenclature.....          | 127 |

## O.

|                          |     |
|--------------------------|-----|
| Octohedron.....          | 123 |
| Oil of hempseed.....     | 315 |
| " of bitter almonds..... | 317 |
| Oils fixed.....          | 314 |
| " volatile.....          | 319 |
| " drying.....            | 315 |
| Olefant gas.....         | 163 |
| Olive oil.....           | 315 |
| Opium.....               | 329 |
| Organic chemistry.....   | 285 |
| Oxalic acid.....         | 291 |
| Oxides.....              | 134 |
| Oxygen.....              | 130 |
| Oxy-salts.....           | 263 |

## P.

|                      |     |
|----------------------|-----|
| Palladium.....       | 259 |
| Peat.....            | 156 |
| Pearl-ash.....       | 281 |
| Pectine.....         | 310 |
| Petroleum.....       | 332 |
| Phosphates.....      | 276 |
| Phosphorescence..... | 71  |
| Phosphori.....       | 71  |
| " solar.....         | 71  |
| Phosphorus.....      | 178 |
| Photometer.....      | 74  |
| Pigments.....        | 338 |
| Pitch.....           | 324 |
| Plants food of.....  | 289 |
| " growth of.....     | 288 |
| Platinum.....        | 256 |
| Plumbago.....        | 155 |
| Potassa.....         | 213 |
| Potassium.....       | 209 |
| Pyrometer.....       | 37  |

## Q.

|                      |     |
|----------------------|-----|
| Quercitron bark..... | 338 |
| Quinine.....         | 305 |

## R.

|                            |     |
|----------------------------|-----|
| Radiation of heat.....     | 26  |
| Red dyes.....              | 337 |
| Refraction of light.....   | 64  |
| Reflection of light.....   | 63  |
| Resin.....                 | 323 |
| Respiration of plants..... | 288 |
| Rock candy.....            | 312 |
| Rhodium.....               | 259 |
| Rum.....                   | 343 |

## S.

|                            |     |
|----------------------------|-----|
| Saccharine fermentation... | 342 |
| Safflower.....             | 357 |
| Salts.....                 | 261 |
| Sandarach.....             | 325 |
| Sanguinaria.....           | 306 |
| Sealing-wax.....           | 327 |
| Selenite.....              | 267 |
| Selenium.....              | 194 |
| Shellac.....               | 325 |
| Silica.....                | 198 |
| Silicon.....               | 196 |
| Silver.....                | 252 |
| " alloys of.....           | 205 |
| Snow.....                  | 48  |
| Soot.....                  | 156 |
| Soap.....                  | 317 |
| Soda.....                  | 214 |
| Sodium.....                | 213 |
| Starch.....                | 307 |
| Steam.....                 | 53  |
| Steam engine.....          | 55  |
| Steel.....                 | 228 |
| Strontia.....              | 212 |
| Strontium.....             | 218 |
| Sublimation.....           | 335 |
| Sugar cane.....            | 311 |
| " candy.....               | 311 |
| " of grapes.....           | 312 |
| " of lead.....             | 294 |
| Sulphates.....             | 264 |
| Sulphur.....               | 174 |
| Sulphuric ether.....       | 340 |
| Sympathetic ink.....       | 233 |
| Synthesis.....             | 16  |

## T

|                  |     |
|------------------|-----|
| Tannic acid..... | 299 |
| Tar.....         | 324 |

|                        |     |
|------------------------|-----|
| Tartar.....            | 291 |
| " emetic.....          | 298 |
| Tartaric acid.....     | 298 |
| Tellurium.....         | 243 |
| Terrestrial light..... | 71  |
| Thermometers.....      | 34  |
| Thorium.....           | 223 |
| Tin.....               | 231 |
| Titanium.....          | 242 |
| Tragacanth.....        | 300 |
| Tungsten.....          | 238 |
| Turmelie.....          | 338 |
| Turpentine.....        | 321 |
| Type metal.....        | 248 |

## U

|                 |     |
|-----------------|-----|
| Ulmic acid..... | 303 |
| Uranium.....    | 241 |

## V

|                              |     |
|------------------------------|-----|
| Vanadium.....                | 237 |
| Vaporization.....            | 40  |
| Vegetable acids.....         | 291 |
| " alkalies.....              | 304 |
| " chemistry.....             | 290 |
| Verdigris.....               | 295 |
| Vermillion.....              | 338 |
| Vinegar.....                 | 294 |
| Vinous fermentation.....     | 344 |
| Vitriol, blue.....           | 269 |
| Voltaic pile.....            | 95  |
| Voltaic electric induction.. | 101 |

## W

|            |     |
|------------|-----|
| Water..... | 142 |
| Wax.....   | 330 |
| Wines..... | 344 |

## Y

|                  |     |
|------------------|-----|
| Yeast.....       | 342 |
| Yellow dyes..... | 337 |
| Yttrium.....     | 223 |

## Z

|               |     |
|---------------|-----|
| Zaffe.....    | 233 |
| Zinc.....     | 228 |
| Zirconia..... | 224 |

≡ Air ones rec. by Leon  
Sodium potassium

Compound Benzols

*Phacelium haysianum* Nutt.

1. 15 miles } has much  
 2. 12 } acid or base?

Sails

Sacred to the  
of the  
from the  
of the

Haloid salt  
Chloride of sodium.

Oxides derive their name  
from Oxygen -

Oxygen is an acid  
Say it is not! former  
acidic oxide

## Compound Bodies

| 1 <sup>st</sup> Acids - | 2 <sup>nd</sup> Bases - | 3 <sup>rd</sup> Neutrals - |
|-------------------------|-------------------------|----------------------------|
| sour taste              | alkalies                |                            |
| changing colors         | other oxides            |                            |
| combine with bases      | higher                  |                            |
| Carbonic acid           | Protoxide               |                            |
| hydrochloric ac.        | Deutoxide               |                            |
| terminations            | Trioxides forms an acid |                            |
| higher - hyper          | highest                 |                            |
| lower - hypo - ox       | Peroxide                |                            |

## Nomenclature

Acids  
Oxygen-acids - and other ac.  
derive their name  
from the other  
element  
as many as 1 on both  
elements  
higher proportion and  
in it - lower and  
hypo - & per - and  
hyper



Carbon + nitrogen - combined  
make Cynogen

in

Soda water

Beer & brand

Carbonic acid

Carbonic acid - water

Carbonic acid - water & CO<sub>2</sub>

Oxide compound of hydrogen & carbon



